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VOLUME 27 | MARCH 21, 1938 | NUMBER 6

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VOLUME 27 | MARCH 21, 1938 | NUMBER 6

CONTENTS OF THIS ISSUE

Contents of previous issues can be found by consulting the Industrial Arts Index at your library

General

Temperatures in Drying—Their Effect on Cost of Operation and Wear Resistance of Textiles..... 141
B. R. Andrews

Physical and Chemical Textile Testing—VII..... 144
John H. Skinkle

Book Review 164

Trade Notes—New Products..... 165

Proceedings of
American Association of Textile Chemists and Colorists

Calendar of Coming Events..... P147

Color Measurement in the Dyestuff Industry with Special Reference to Fastness Tests..... P148
I. H. Godlove

In Defense of Lanital..... P156
Hector C. Borghetty

Editorials

Mill Laboratories 159

Coming Issues 159

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AMERICAN
DYESTUFF REPORTER

VOLUME 27 MARCH 21, 1938 NUMBER 6

Temperatures in Drying

*Their Effect on Cost of Operation and Wear Resistance of Textiles**

B. R. ANDREWS†

THE manufacture of finished textile products is probably one of the oldest industries. In all the years since this industry has come indoors, drying between different operations in the production of fabrics has constituted a process vitally affecting quality. Because of its recurrence many times in the steps from raw stock to finished article, drying is a large item of cost. Yet progress, to date, in learning to dry the maximum quantity of first-quality goods at minimum expense seems altogether too small for the amount of attention that has been given to it by makers of cloth and manufacturers of equipment for its drying. Engineering aspects of drying where latent heat of vaporization is supplied by a gaseous medium are exceedingly complicated with an unusually large number of variables. Perhaps an attempt to view too many factors at once has retarded a more complete study of each individual factor or variable. This paper, therefore, is intended to deal only with temperature in drying with air or superheated water vapor.

Drier temperature affects character and quality of the fiber whether it be in raw stock, sliver, top, yarn, warp, or any of the various finishing operations. It affects the color, handle, and wearing quality. Whites can be yellowed by it; dyed goods can be shaded. Surface feel can be made harsh or soft. Handle can be changed in drying so that drape and ability to be creased or to retain such creases are altered enough to be recognized by the ultimate consumer. All of these effects take place at temperatures that vary with method of application of heat and relative quantity of moisture remaining in any of the fibers when they leave the drier, as well as the length of time the goods retain the heat absorbed.

COST OF DRYING AFFECTED BY TEMPERATURE

Temperature in drying affects the cost of the operation, because required heat input, power to move the drying medium, and output of any given drier are all involved with the temperature used. Heat input to a drier supplies radiation and leakage losses from its exterior, heat in the exhausted vapor and drying medium, latent heat of evaporation of water from the material being dried, and increased sensible heat of that material.

Radiation losses can be cut to small values without making an expenditure for insulation that fails as a good investment. Leakage losses can be almost entirely eliminated if the housing is well-built. Loss out of the exhaust fan is more involved. This is the item that is most affected by the drying temperature and the factor that determines the thermal efficiency of the drying machine in cases where the foregoing losses have been properly reduced.

The exhaust carries away the water vapor. Consequently, where air is the drying medium, the volume of exhaust is greatest when its water content is low and smallest when the water content is high. However, the capacity of the drier is highest when relative humidity is low, and lowest when the relative humidity is high. Therefore, high drier and consequent high exhaust temperatures give both high drier capacity and lower relative humidity in the exhaust, with a relatively small exhaust volume but a high total heat per cubic foot. If, however, superheated water vapor is the drying medium, it is always received by the drier from the water vaporized out of the material being dried at the temperature of vaporization, and the volume of the exhaust is only that of the water vapor evaporated from the product of the drier.

OPERATION AT HIGH TEMPERATURE MORE ECONOMICAL

To apply the foregoing to an actual case so that the rather vague terms "high " and "low" can be more accurately determined, five imaginary driers are analyzed in Table 1. They are presumed to have like methods for disposing of the material in them and applying the drying medium and to be capable of fast drying. Each receives the same goods with equal wetness and delivers them with equal regain.

*Presented at a meeting of the Textile Division, Boston, Mass., Oct. 15, 1937, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

†Andrews and Goodrich, Inc., Boston, Mass.

TABLE 1
Analysis of Five Driers

Drier No.	1	2	3	4	5
Drying medium	Air	Air	Air	Air	Superheated water vapor
Exhaust temperature, F.	180	180	180	280	280
Relative humidity of exhaust, per cent	5	15	35	5	...
Drier lengths, ft.	200	258	430	100	100
Steam per pound of water evaporated, lb[a]	4.50	1.98	1.63	1.70	1.25
Power required to circulate drying medium, hp.	60	75	130	30	30
Steam and power cost per 1000 lb. of water evaporated	$3.00	$1.93	$2.45	$1.23	$0.99

[a] Exclusive of sensible heat added to material.

The first three have an exhaust temperature of 180 F and operate with relative humidities of 5, 15, and 35 per cent, respectively; the other two have an exhaust temperature of 280 F. No. 4 uses air and exhausts with 5 per cent of vapor and No. 5 uses superheated water vapor only. Their size is adjusted so that each evaporates 1000 lb. of water per hour. Power is charged at 1.25 cents per hp-hr and steam at 50 cents per 1000 lb. These figures are theoretical calculations based on well-established data, and, because no allowance has been made for leakage, they indicate a cost which is slightly below possible commercial practice, yet they do parallel actual field results closely.

Circumstances may compel adoption of any one of the five combinations at times, but those operating with higher temperature are more economical to use and occupy the least floor space. Furthermore, while new plants are built from time to time and radical rearrangements of machinery are sometimes made, it is usually desirable, if not actually necessary, to make provision for increased production or reduced operating costs in floor space already allocated in existing machinery layouts. Such arrangements of equipment generally have also determined the number of operatives to each drier or range in which the drier is a part. Therefore, if a plant can increase the capacity of its drying units without enlarging them and at the same time reduce operating cost per unit of production, the total saving in the cost of manufacturing an article requiring four or five separate dryings is large.

STUDY OF DRYING TEMPERATURES NOW BEING MADE

A realization of this condition has manifested itself in the work now being undertaken by the U. S. Institute for Textile Research in a study of temperatures in drying. This should, in time, greatly augment the meager fund of information now available as to just how high a temperature can be used in a properly designed drier without detriment to the quality of the product dried. However, it will take years to get test information of this sort into usable form so that its findings can be applied to manufacturing operations. In the meantime, progress toward better drying can be materially hastened by a more general acquaintance with the accumulated knowledge of the effect of velocity and direction of application of the drying medium, the importance of the point at which the drying operation is discontinued, and the care of goods immediately after drying.

To produce goods that are suitable, all plants have been obliged to give much time and study to the effect of driers on their product. Drawing definite general conclusions from the results of their experience is difficult because of the many variable quantities previously mentioned and because few plants measure drier temperatures in the same way. Thermometers are frequently located where they are convenient to read rather than where they will indicate the temperature at the material. However, by taking temperatures at the material in a great many driers over a long period of years, it can be stated with soma degree of accuracy that the maximum temperatures at the cloth given in Table 2 are in use by plants making high-grade goods and using no greater heat than they feel is consistent with quality. While these temperatures indicate an approximate cross section of today's practice, it should be borne in mind that higher temperatures are already being used.

TABLE 2
Maximum Temperaures at the Cloth Used by Drying Plants, Deg. Fahr.

	Adequate circulation	Inadequate circulation
Cotton stock	270	240
Wool	250	160
Cotton piece goods	320	260
Worsted piece goods	250	180

Furthermore, when more accurate methods of reading the moisture content of delivered goods are available with dependable means of translating these continuous readings into drier speed, still higher temperatures can be used in these same driers because overdrying, which is now unavoidable, will be eliminated.

FAST-DRIED GOODS HAVE GREATER WEAR RESISTANCE

Results of many years of work with textile driers and drying indicate clearly that economies of drying at higher temperatures are possible for many more textiles and textile plants than now enjoy them. In some cases, these savings can be made on existing driers, although in general, the existing method of applying the drying medium requires revision to protect the fibers and the quality. Tests made by Sampson, Gautreau, & Rolland in the laboratory of Andrews & Goodrich, Inc., on fabrics, the fibers of which had never been subjected to a temperature higher than 160 F, seem to emphasize the foregoing statement, and the following description, with analysis of one group of these tests, is given to indicate where the field of better drying seems to lie. Samples of white and dyed worsted gabardine were dried fast from 100 per cent wetness to 5 per cent at varying temperatures from 140 to 340 F with rapid, efficient air circulation. Another set was similarly dried except that it was left in the drier for 10 min. after

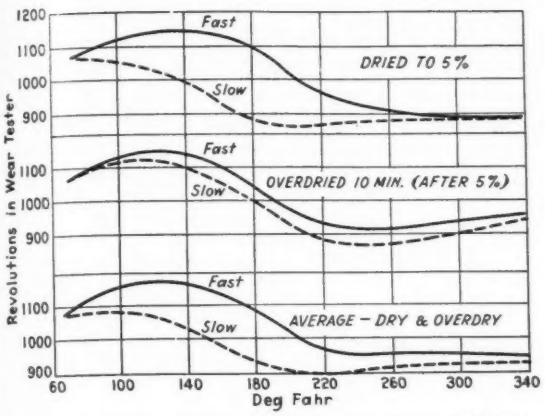

Fig. 1 Influence of rate of drying upon wear resistance

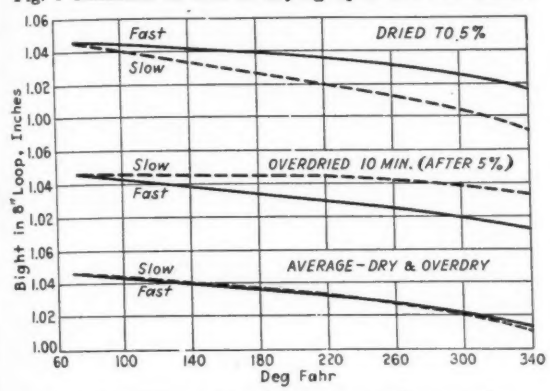

Fig. 2 Resistance to bending of garbardine samples

the 5 per cent point had been reached. Others were treated in the same way but slowly dried, with less rapid air circulation that was not so well applied.

These samples were tested for wear on a combination machine giving in sequence four smooth abrasions, one light blow from a hammer, and one light abrasion with emery paper, all under constant humidity and after like rest periods between drying and wear. Results of this test are illustrated in Fig. 1.

Test pieces, after pressing, were each held together at their ends and accurate measurements made across the bight thus formed, to test for stiffness. Fig. 2 gives the results of this test. Again they were tested for ability to be creased and to recover their original shape, by measuring the change in the length of strips given nine creases. All samples were hung for the same time under the same conditions of humidity and temperature before measurement. The results of these two tests are presented in Fig. 3.

Lastly, each sample was tested for elasticity by measuring its elongation under like tension per inch of width and for recovery by taking the time required for the piece to readjust its length. Fig. 4 shows the results of these elongation tests.

To avoid confusion, tests of chemical changes or tensile strength, regain, and the like are omitted, and consideration is given only to those measurable properties that enter

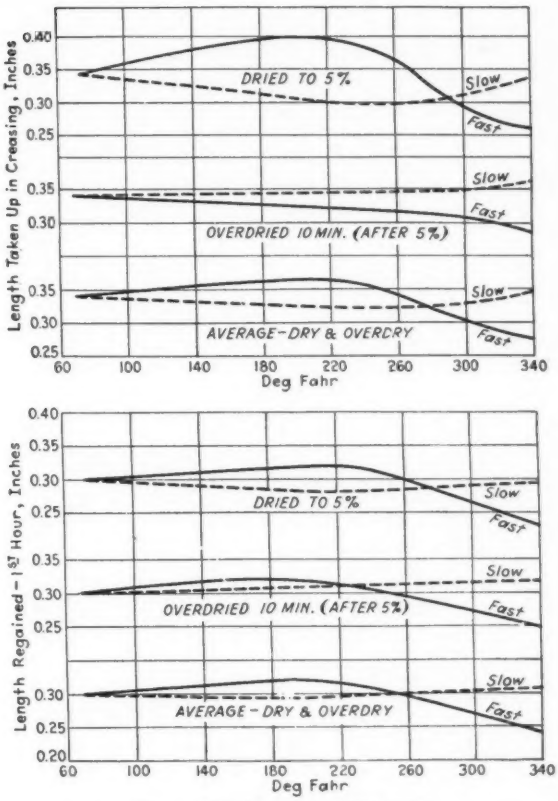

Fig. 3 Results of creasing tests
(Upper chart shows influence of rate of drying upon length taken up in creasing; lower chart shows the ability to recover original shape.)

into judgment of feel, handle, and appearance under the eye and use in the finished garment. However, as a matter of interest, the effect on tensile strength is given in Fig. 5.

From the results of those tests where the drying operation was stopped when the water in the cloth equaled 5 per cent of its dry weight, it can be stated that ability to resist this type of wear-testing machine decreases steadily from the use of drier temperatures of 140 to 180 F. in the case of slow drying. Fast drying, however, actually increases resistance to wear at temperatures below 180 to 185 F. and permits use of 70 to 80 deg. higher temperatures than slow drying for like wear properties. Higher drying temperatures beyond these points make little or no change in the number of revolutions of the wear tester required to break the samples.

Recoverable elongation per unit of tension is greater for fast-dried and less for slow-dried goods for each succeeding temperature from 140 F. up, but the rate of recovery for such stretching, expressed in percentage of its elongation, is not appreciably affected by the temperature at which the cloth is dried unless temperatures above 200 F. are used. Resistance to bending is also greater for fast-dried goods than for slow, and in each case is less for each succeeding temperature above 140 F. From 140 to 300 F. fast-dried goods take sharper pressed creases and hold them longer than those dried slowly.

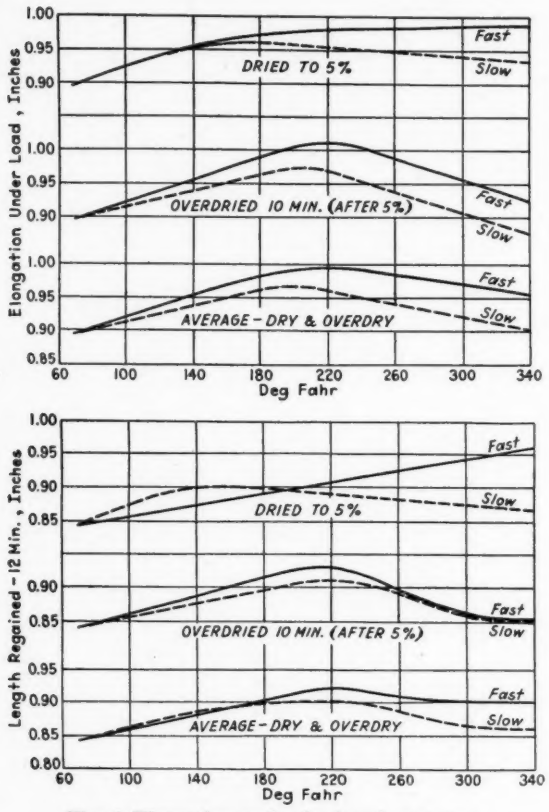

Fig. 4 Elongation under load and recovery (After the samples had been subjected to similar loads for 12 min., they showed the results given in the upper chart. The lower chart shows the recovery of the samples in 12 min. after removal of the load.)

If, however, the goods are overdried, little difference is found in ability to resist the wear-testing machine whether this drying is fast or slow. The curve goes down from 140 F. until it flattens out at about 220 F. Recoverable elongation, while again slightly in favor of fast drying, increases from 140 F. to about 220 F. and decreases from that point to 340 F. Recovery from stretching is a little

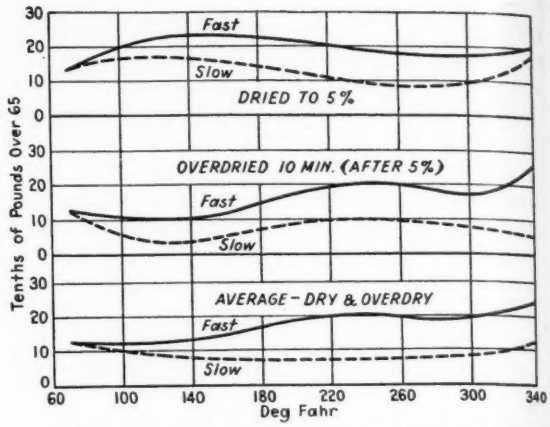

Fig. 5 Effect of drying rate on tensile strength

faster in slowly dried fabrics but does not vary much with the temperature at which they are dried. From the foregoing, fast drying at temperatures under 280 F. appears to cause high-count worsted gabardines made from fine wool to stand up in the wear-testing machine longer, stretch easier, resist bending more, take pressing better, and hold it longer than slow drying, provided they are not seriously overdried. Furthermore, the same statement is true for fast drying at 240 F. as against slow drying at 180 F.

Results of all of these tests are confirmed by the operation of production driers in finishing plants where contact with heated surfaces, if made at all, is intermittent and brief and the time to reach a condition of 5 per cent water content from well-extracted goods is no longer than 2 to 3 min. for loose cotton or wool and worsted piece goods and from 10 to 30 sec. for cotton piece goods. Analysis of the foregoing data indicates that for worsted cloth driers

(1) Higher temperatures improve drier economy.

(2) Higher temperatures are permissible for like quality if drying is faster.

(3) At any temperature, fast drying improves quality.

(4) Maximum temperature limits for like quality vary inversely with the drying time.

—♦♦—

Physical and Chemical Textile Testing-VII

JOHN H. SKINKLE*

PART I—PHYSICAL TESTING

(Continued from February 21, 1938, issue)

Chapter 8—Strength and Stretch Testing of Fibers, Yarns and Fabrics

INTRODUCTION AND DEFINITIONS

THE determination of the strength of a textile material gives us very useful information as to that material but a word of warning as to the interpretation of the results might not be amiss. Strength as an imitative test is of no value; that is, in actual use a textile material is not subject to a slowly and steadily increasing load as is used in the strength test but rather to abrasive action and smaller repeated loads. Strength as a measure of uniformity is a very useful test, since a change in any physical property or a change in the chemical constitution of a textile material will nearly always result in a change

*Department of Chemistry, Lowell Textile Institute, Lowell, Massachusetts.

in strength; even here, however, a warning must be voiced—strength tends to give minimum rather than average results. To explain this, consider the measurement of twist in a yarn, we untwist ten inches of yarn and measure the total number of turns—the average twist of the ten inches of yarn is thereby obtained. If we break the same ten inches, the force measured is not the average strength of that ten inches, but the strength of the weakest spot in that length of yarn. The principal value of the strength test is its use to measure the quality of the textile material, which is dependent upon the qualities of the constituents of the material and the quality of the work done upon it. For example, the quality of a yarn is dependent upon the quality of the fiber and the quality of the spinning operation; the quality of a cloth is dependent upon the quality of the fiber, the spinning operation, the weaving operation, and the finishing operation. It follows, then, that strength is the determination of the result of several variables and is a rather complex quantity; wherever possible then strengths should be measured in comparison with other samples which differ only in one aspect from the unknown sample.

Stretch is desirable in some cases, especially if it is of the elastic type; knitted goods, for example, are meant to be tight fitting and to yield readily to forces. In general, however, stretch is undesirable because the fabric is meant to keep its shape and dimensions. The combination of stretch and strength, the method of obtaining which will be given later, gives the work necessary to break the sample and is a measure of the toughness of the material, which is more nearly related to wearing ability than either strength or stretch alone. Consider as two extremes ramie which has a high strength but low stretch, and wet rayon which has a high stretch but low strength—the product of the two in both cases is low, both are lacking in toughness. Other fabrics may have less strength than ramie and less stretch than wet rayon, but the product of the two is greater and consequently they wear longer and better.

Unfortunately, the nomenclature of strength and stretch testing is not yet standardized, so we must first define the terms which we are about to use. A stress is the force or load acting upon a sample, a strain is the change in dimension resulting from the stress. Stresses may be tensile stresses which result in an increased length of sample, compressive stresses which result in a more compacted sample, and torsional stresses which result in a twisted sample; in this chapter we shall consider only tensile stresses. Breaking stress, breaking load, breaking strength, and tensile strength all refer to the force acting upon a sample at the time of failure, this is usually the maximum force applied. Bursting strength is the force applied to break a fabric when applied at right angles to the fabric and uniformly distributed over a given area. Tenacity is the breaking strength of a sample expressed in units of force per unit of cross-sectional area of the sample. in the case of rayon or silk it is the breaking strength in grams per denier. Stretch or extension is a strain resulting in a greater length; two types of stretch exist, either or both of which may be present in a given test—elasticity and elongation. Elasticity is recoverable stretch, elongation is non-recoverable stretch. If a sample 10 inches long is stretched until it is 13 inches long, it has a stretch of 3 inches or 30 per cent; if we now release it and it returns to a length of 11 inches; it has an elasticity of 2 inches or 20 per cent and an elongation of 1 inch or 10 per cent. Stretch, elasticity, and elongation may be given in units of length but are generally expressed as per cent of the length of sample broken, i.e., the length of the sample between the gripping jaws of the testing machine, called the gauge length. Elastic limit is the load below which the sample shows elasticity and above which it shows elongation. Yield point is a wholly theoretical figure and is the load at which elongation would begin provided the material had no elasticity; this value cannot be directly measured but may be obtained from a stretch-load curve. Elastic limit and yield point are usually determined only on rayons and silks and are expressed in grams per denier.

Based on the method of loading, strength testing machines may be classified as:

1. Manually loaded by weights, chains, electromagnet, or trickling water.
2. Pendulum type.
3. Constant specimen-rate-of-load type.
4. Impact or ballistic tester.
5. Bursting tester.

MANUALLY LOADED STRENGTH TESTERS

The manually loaded type is obsolete except for a few types of single fiber testers:

1. O'Neill tester.
2. Bowman tester and Matthews tester.
3. Barratt tester.
4. Krais (Deforden) tester.

The O'Neill single fiber tester consists essentially of a pair of clamps for the fiber of which the top one is fixed and the lower attached to a floating "bob." With the fiber in place, water is run out of the cylinder in which the bob is floating until the fiber is straightened, then a graduate is put in place. Water is run out of the cylinder into the graduate until the fiber breaks, the amount of water indicates the breaking strength of the fiber; if testing at a constant humidity, calcium chloride solution of the same partial pressure as the atmosphere is used instead of water. The Bowman and the Matthews fiber testers use an analytical balance in which one pan is replaced by the jaws, loading is done by placing weights on the other pan or using a chain for weighting the other arm of the balance. Barratt's apparatus is also an equal-arm balance in which the loading is done by an electromagnet. Krais' apparatus is an equal-arm balance in which the loading is done by running water into a cup on one side of the balance.

PENDULUM STRENGTH TESTERS

The pendulum tester is the type in common use for all textile materials. The specimen is strained by a uniform

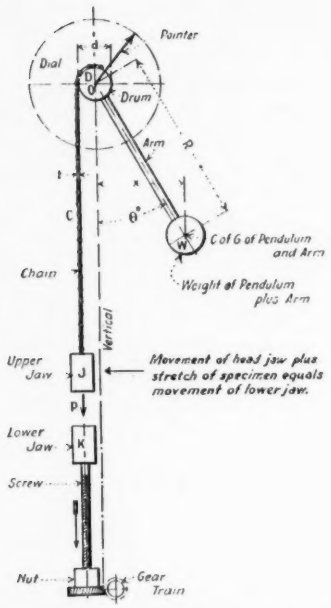

Fig. 34 — Principle of Pendulum Strength Tester.

Courtesy, Henry L. Scott Co.

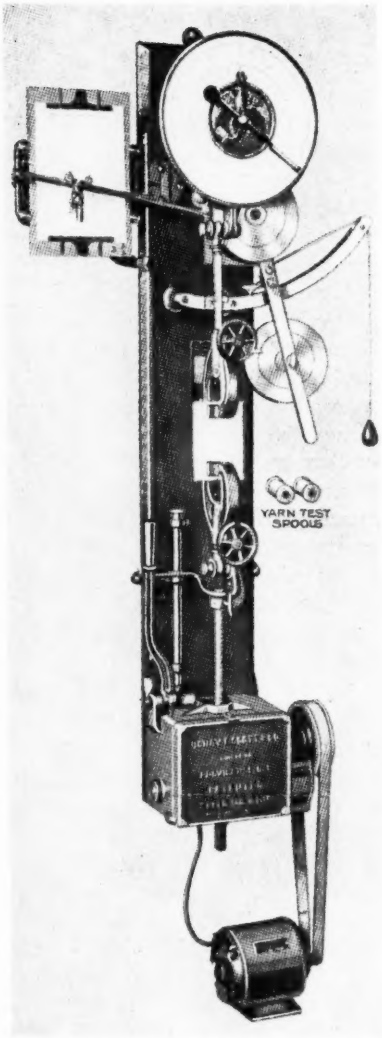

Fig. 35—Pendulum Strength Tester with Autographic Recorder, Motor Driven.

Courtesy, Henry L. Scott Co.

movement of a pulling jaw or clamp to which one end of the specimen is attached; the other end of the specimen is held by a jaw or clamp attached to a pendulum; the pendulum is displaced from its normal vertical position by a pull on the specimen and the amount of displacement indicates the load. The pendulum is lightly ratcheted to a notched sector so that after the specimen breaks, the pendulum (and the pointer geared to it) will remain stationary at the maximum load.

The pendulum tester consists of three main parts:

1. Straining mechanism
   a. Constant speed motor, gear train, nut, and screw; or
   b. Cylinder and piston, with hydraulic pressure
2. Jaws or clamps holding the specimen
3. Loading and recording mechanism
   a. Chain
   b. Drum
   c. Pendulum arm and weight
   d. Pointer and scale
   e. Notched sector and ratchet
   f. Autographic stretch-load recorder.

The tester may be operated by a motor or by hydraulic pressure. Jaws are available for various tests on cloth or yarn. The pointer may be attached to the drum and indicate on a circular scale or it may be attached to the end of the pendulum and indicate on a scale engraved on the notched sector. The autographic recorder (not always present on a strength tester) consists of a flat plate moved vertically by an attachment to the lower jaw and a pen which moves over a guide horizontally by attachment to the pendulum; it therefore records stretch vertically and load horizontally. Figures 34 and 35 show the principle and the parts of a motor driven strength tester with an autographic recorder as used on cloth. This is the most common type of tester of capacity up to 500 pounds used in this country. Older forms were operated by hand turning but these gave very variable results and have been abandoned. Machines are often so made that removing one weight from the pendulum will convert it to a machine of lower capacity, usually one-half the original capacity.

Some of the variations in pendulum testers are:

1. Hydraulic type mentioned above.

2. Rubber testers—provided with a very long screw because of the enormous stretch.

3. Serigraph testers—made especially for silk fiber, yarn, and cloth testing. Made a little more finely than the ordinary tester and always provided with an autographic recorder.

4. Horizontal tester (Figure 36), the same in principle as the ordinary tester but of high capacity—800, 1000, 2000 pounds.

5. Single strand testers (Figure 37), similar in principle to the ordinary tester but of much lower capacity, never over 50 pounds, and usually reading in grams or ounces.

(Continued on page 160)

PROCEEDINGS OF THE

American Association of Textile Chemists and Colorists

MARCH 21, 1938

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CALENDAR OF COMING EVENTS

Meeting, New York Section, Chemists Club, New York, N. Y., March 25, 1938.

Meeting, Northern New England Section, Andover Country Club, Andover, Mass., "Wool Meeting," April 1, 1938.

Meeting, South Central Section, Andrew Johnson Hotel, Knoxville, Tenn., April 9, 1938.

Meeting, Philadelphia Section, Penn A. C., Philadelphia, Pa., April 22, 1938.

Meeting, Southeastern Section, Hotel Dempsey, Macon, Ga., April 23, 1938.

Meeting, Council, National Bureau of Standards, Washington, D. C., 9:30 A. M., April 30, 1938. Research Committee will meet in the afternoon of the same day. Note: These meetings were originally scheduled for April 29th.

Spring Meeting, Piedmont Section, Greensboro, N. C., May 7, 1938.

Annual Meeting and Convention, Atlanta, Ga., December 2 and 3, 1938.

Color Measurement

in the Dyestuff Industry with Special Reference to Fastness Tests*

I. H. GODLOVE†

WHENEVER my thoughts have been turned to color measurement, they have recalled two men. One was a man who always wore a monocle; and, when asked why, explained that thus "he would see no more than he could understand." The other gentleman explained why he had named his daughter Ann by saying that "she was the most indefinite article" he knew. Color measurement with instruments in a sense arises out of the difficulty of understanding what we see and the indefinite nature of the message which the eye sends to the brain.

These remarks do not forecast, as might be supposed, a sales talk for instruments to replace the eye. If anyone besides myself has read the abstract of my paper, he may have guessed that I have considerable admiration for the human eye; and therefore very much respect for you colorists who have learned to depend on your eyes and put the burden of proof on the salesman who has an instrument to sell. On the other hand, I shall attempt to show that certain instruments do assume the *proper* function of the monocle, not the foolish one of my friend of limited understanding. That is, certain instruments and simple visual aids can supplement the eye to assist definiteness. Instead of keeping out information, it is better to get more facts and work at the other end to stimulate understanding. We want to get rid of the Anns, the "indefinite articles," and substitute Pandoras, who take the lid off to get at the facts.

Note that I spoke of "considerable" admiration and "very much" respect for colorists and their eyes. You are no doubt satisfied that I didn't say merely "a trace of respect," or "noticeable respect." You do not demand definite numerical specification of the amount of respect, "or else"—the shower of ripe tomatoes. Being sensible men, you do not see the value of precise measurement and exact specification of quantities inherently so indefinite. That would be a case of straining at a gnat and swallowing a camel. Yet it is safe to say that some of you have, or will have, listened to the Lorelei song of the measuring siren (meaning the persuasive literature of "exact" measuring instruments), without knowing where the glamorous lady is leading you. I am all for the lady and adventure; and I intend only to give you a preview of the paces she may put you through. But also, I mean to point out riparian adventure on the opposite shore. On that bank, the lure will be a fine pair of Circe eyes connected to an understanding brain. The Lorelei's make-up often includes the photo-electric cell. On the other bank, Circe carries, like every one of us, two fine photo-electric cells on either side of her nose. To stretch my metaphor pretty far, I shall recommend going up the river with a view of both banks, seeking adventure on either shore, (that is, through courting either the lady of the instruments or of the eyes), going to either bank only when the particular business at hand forces our presence there; but leaving either lady flat when a different problem might be best treated on the other bank. Especially, I shall recommend never being so intrigued by Circe as to forget Lorelei, or to dally so long with Lorelei that Circe's simple charms are lost sight of.

Now dropping metaphor, I intend to give a list of practical measuring problems and to recommend instrumental or visual methods for each in turn.

One visual problem will be that of securing more definiteness in the rating of fastness tests. A five-step scale, reading like: "A trace," "noticeable," "appreciable," "considerable" and "very much" may do for rating respect for colorists and their eyes; but for rating the color changes of fastness tests, a more definite scale is needed. My main thesis is: Some problems are solved most successfully with certain instruments, others by "visual" methods, sometimes by judicious combination of these, and always with a proper understanding of their relation.

Some of the fundamental questions which must be answered are: What do color-measuring instruments measure? Is it what the eye sees? Can we measure color without optical instruments? Is it possible to convert instrument measurements to a specification of what the eye sees? Are the measurements by spectrophotometers and colorimeters measurements of color?

The answers to these questions obviously depend on the nature of the color itself and on the quantities measured by instruments. There is so much misunderstanding of color that I shall consider the instruments first, color last.

Here is some black velvet. No matter what the color of the light that falls on it, it absorbs most all; that is, reflects none. Here is a block of magnesia.[2] It reflects practically all the light, of any color. We can direct a light measuring instrument at these; white would give a reading at the top of the scale, black at the bottom. Such a light measurer, we call a photometer.

Here I have a gray sample. By careful inspection by a

*Presented at Annual Meeting, Philadelphia, Pa., Dec. 4, 1937.

†E. I. du Pont de Nemours & Co., Inc.

[1]A great many of the charts, graphs and other exhibits, which were used to illustrate this paper, were shown in colors. Apart from their color, they were so numerous that space does not permit their reproduction even in black and white. The reader is therefore asked to use his imagination somewhat; but in some cases footnotes will aid the imagination with brief descriptions.

[2]This is the whitest of all common materials.

large number of people, it has been picked out to give an equal contrast with white and black. It is a *mid-gray*. Does it reflect 50 per cent of white light? We find by measurement that it does not; its reflectance is about 20 per cent. To put this the other way around, this sample (designated N7.8)[3] which does reflect about 50 per cent looks almost white. Also, here is a pair of light grays (N9 and N8) differing by about 19 per cent in reflectance; and here a dark pair (N5 and N1) nearly as much (17 per cent). The contrast in the dark pair is enormous compared to that of the light pair. Obviously, light-measuring instruments operate differently than the eye. Here we have a decimal scale of grays, extending from black to white, which look evenly graded to the eye. The reflectances are in the order: 100, 73, 54, 39, 27, 18, 11, 6, 2.9, 1.1 and 0.0 per cent.

This scale is an extremely simple thing visually. It is not so simple physically. Its use for certain problems is relatively simple. Thus, suppose we have to rate the cleaning power of detergents. We set up a standard dark gray soiling liquid and put it on a standard fabric. The lighter the detergent makes the sample, the more efficient it is. This is a purely visual problem. Once a scale like our ten-step scale has been set up, or one with more steps, all even, no physical instrument whatever can handle the detergent problem with the neatness and dispatch of such a scale and the human eye. Some photometers may seem to do so at first thought, because they can measure reflectances precisely to a few tenths of a per cent, or better. But it can be shown that we thus have only a pseudo-accuracy; and the use of the photometer involves complications. Thus, suppose detergent A cleans a gray originally reflecting 1 per cent until it reflects 49 per cent, a gain of 48 per cent. A competing detergent B cleans it to 97 per cent reflection, a gain of 96 per cent, that is twice as much lighter. Is B twice as efficient as A? The answer is: "Most certainly not." B is only about 30 per cent more efficient than A. Why do I say this?

Such a problem is a consumer problem. The consumer is interested only in how the sample looks after it is cleaned, how much lighter it is. It is utterly immaterial to him what percentages of light of any wave length are reflected. This problem illustrates the fact that very often the ultimate consumer is interested only in how the product looks. He will be willing to accept instrument measurements only insofar as they give him accurate information on the question of how the samples look. With the manufacturer, it very often is a much different story.

We can use a photometer after we have determined what successive percentages of reflected light give equal contrasts (under certain conditions). I have already stated the figures. Here they are shown as a graph of reflectance versus lightness or darkness[4]. You see the first few per cent of reflection are much more effective in producing lightness than the last few. There is operating the same effect which in economics we call the "law of diminishing returns."

A little thought shows this to be a familiar fact. If we are carrying a 10 pound weight, another 10 pounds seems a big increase; but if we are carrying 100 pounds an additional 10 doesn't seem so much.

Up to the present I have talked only about grays, i.e., neutral colors. Also, I have said nothing about the light illuminating the samples, because, with the particular grays I used, it makes no difference what light is used. This is not always the case, and we must turn a moment to the light.

The essential difference between radio waves, infra-red or heat waves, visible light waves, ultraviolet, X-rays, etc., is merely the wave length. Thus, whereas we measure radio waves in meters, we measure visible light in a unit, the millimicron, a billionth of a meter. Between the shortest and longest possible waves, only an extremely narrow band affects the eye by producing visible light. Practically, we obtain the spectrum by passing "white" light through a glass prism, when the variously colored rays are spread out in fan-shaped order. To use the spectrum in measurement, we employ a narrow slit and an arrangement to isolate at will any desired wave length. Thus, the *spectroscope* is essentially a "wave length selector." When we combine it with a light measurer, or photometer, we have a *spectrophotometer*.

By having a number of people look into a spectroscope we can obtain the following rough relation between "color" and wave length (using here R for red, O for orange, etc.):

Hue	*Wave Length*	*Hue*	*Wave Length*
R	700	G	515
RO	631	GB	498
O	600	B	473
OY	592	BV	439
Y	577	V	400
YG	568	RV	700 and 400, etc.

This relation seems at first thought a simple and convenient one to use: Measure the wave length of light reflected, and use it to specify the color. Unfortunately, we find, when we do this, that we have made only a start. In the first place, we can have more or less light, i.e., variations in intensity. This introduces no great difficulty, as we can measure the intensity by the photometer part of the spectrophotometer. But we find that all actual surfaces reflect a great variety of wave lengths. Even our purest red dyeings, for example, reflect some yellow, green, blue and violet light. We must, therefore, measure the intensity of light of each wave length or color in turn; i.e., the distribution of reflection throughout the spectrum.

I shall illustrate this fact and the principle of the spectro-

[3]This is the designation of a light gray in the Munsell system, to be described later.

[4]This is merely the slightly curving line obtained by plotting the percentage reflections, given three paragraphs above, for the eleven steps of the decimal scale of lightness or darkness shown with evenly graduated gray samples.

photometer by means of this simple combination which I have carried in my pocket for many years. Here are red, green and blue filters, which select in turn the reflected light of long, middle and short waves. This selector corresponds to a spectroscope. Here is my scale of grays, marked with percentage reflections, to correspond to a photometer. The two combined represent the spectrophotometer. Here is a 2 per cent dyeing of "Pontacyl" Fast Red AS. I find that when I look through the red filter, the dyeing about matches the gray 7; looking through the green, it appears half way between the steps 1 and 2; and with the blue merely matches step 1. That means that very much red light is reflected, for step 7 reflects about 39 per cent of light of any color. Hardly any green or blue is reflected, for step 1 reflects only about 1 per cent of any light. Here is a lighter dyeing, with 0.1 per cent "Pontacyl" Fast Red AS. All the readings on it are higher. Putting them down in visual steps, with the corresponding reflectances, we have:

	Visual Steps		*Per Cent Reflectance*	
Filter	*Light Red*	*Dark Red*	*Light Red*	*Dark Red*
R	9	6.9	73	37
G	4.2	1.5	12	1.9
B	4.4	1.3	14	1.4

With a spectrophotometer, we go farther. Instead of taking readings of reflectance for three parts of the spectrum, we take them for 20 or 30 wave length regions.

Here we have the spectrophotometric curves for typical dyeings of six hues[5]; practical uses of such curves of course immediately suggest themselves. If *two dyeings, measured under identical conditions,* give identical curves, the colors may be said to be identical. Moreover, the dyeings will match under any light, when seen by any eye. They may therefore be called a "complete match." These complete matches contrast strongly with the great bulk of matches obtained in ordinary commercial practice. For example, an automobile upholstery "taupe" may have been dyed by a mill with a competitor's dyes, of unknown chemical nature. It must be matched with a different combination of dyes, in laboratory or dye house. An excellent match is obtained by the dyer, who used a clear north sky light. The match and standard are returned to the customer, who views them, perhaps when the sky is overcast, with an eye having slightly different sensitivities. He calls the match bad, and the result is disastrous. Such an occurrence cannot happen if the match is a complete match, with identical curves.

But the question at once comes up whether we can ever get, or get within a feasible time, a complete match, with two identical curves. Given the curve of a standard and of every dye in the commercial line, can the standard curve be exactly reproduced by mixing the dyes? Whether the answer is "yes" or "no" depends on what we mean by "exactly"—not in a mere academic sense, but within practical limits. A machinist is asked to turn out a mandrel six inches long, with a tolerance of, say, plus or minus, one thousandth of an inch. Can we give the dyer a tolerance within which the sample color must match standard? For example, could we draw the spectral curve of the standard on an 8" x 11" sheet, and demand that the curve of the match fall everywhere within 1/16th inch of it, up or down? If the dyer could get a match that close, would it be acceptable?

We will find that the answer to our question may be sometimes "yes," sometimes "no."

We already have data which suggest the answer. 1/16 inch may correspond to a 1 per cent difference in reflection. We found with our scale of grays that 1 per cent difference at the dark end would produce a very great contrast; at the light end we might not be able to see a 1 per cent contrast at all. A 1 per cent or 1/16 inch tolerance would be ample for a light pink, but would permit a very bad match of a dark red. Of course, we can easily get around this complication. We can use a logarithmic scale. Or, we could use the scale of reflectances of my ten-step gray scale.

However, we find when we have done this, that we are closer to a solution of the problem; but we are still a long way off. There are a great number of complications. Some of these complicating factors will bring us squarely back to our early question as to *whether instruments ever measure what the eye sees.*

What do we see? We certainly do not see wave lengths! Nor do we see intensities or percentage reflectances. We arrive at these concepts only by an elaborate process of scientific abstraction. Here I have a collection of colors, including grays, scattered at random. Some are dark, i.e., have some resemblance to black. Others are light, resembling white somewhat. Others fall in between; they could be lined up with mid-gray. Obviously, lightness or darkness is one difference between colors. We have said nothing about wave lengths.

When King Solomon was faced with the problem of remembering the host of wives in his harem, he might have classified them, consciously or intuitively, as an aid to memory. There were blondes and brunettes. In his day gentlemen really did prefer blondes. Some were short, others tall. Some were fat, some thin; and there were other less tangible psychic characteristics.

By examining all our colors, we find that they also differ in characteristics other than lightness or darkness. At once we note reds, yellows, greens or blues. This difference we call "hue." Again I do not speak of wave lengths. Here is a circle of 20 hues made of dyeings on cotton[6]. It is noted that some are lighter or darker than others. Here I have a circle of 100 hue steps, this time with every sample half-way in lightness between black and white. Ignoring variations in the glossiness and transparency of colors, is there any characteristic other than lightness and hue? Here are two samples (Y 8/12 and Y 8/6)[7] which are both yellow in hue and both at the 8th step in lightness, but they still differ. One is grayer than the other;

[5]Similar curves may be seen in Hardy's *Handbook of Colorimetry,* which is referred to later.

i.e., there is a difference of dullness or brilliance. Among the random colors we see that some are dull, rather resembling some gray; others are vividly unlike gray. This attribute, characteristic or dimension is called brilliance by dyers. Again I do not mention wave length.

I shall now speak of the three dimensions of color as *lightness*, *hue* and *brilliance*. To specify any color it is necessary to state the three dimensions. To say only that a color is red is as incomplete as to say only that a warehouse is 100 feet high.

To make the dimensions of color clearer, I have here sets of charts having the colors arranged logically according to their three dimensions. They could have been just as logically arranged 2,000 years before Solomon's time, before any one had ever got the idea of wave lengths. This is the Munsell "Book of Color"[8]. Here is a chart of reds, here a chart of violets or purples. Note that there is a row of purples corresponding to each gray step; and in each row the samples depart more and more from gray. That is, on such a chart, hue is constant while lightness and brilliance vary. We also have here arrangements in which lightness is constant. Thus, here is a chart of light colors, and here one of dark colors. They are the 7th and 3rd steps between white and black. There are others at each of the other levels. There is a third kind of chart, on which brilliance is constant and lightness and hue vary.

These charts are like cross-sections of the warehouse of colors. To show the whole scheme we have to show the *color solid*. Here is a diagrammatic sketch of it. Returning to the charts, you may see that the colors are so graduated that the *contrasts* from color to color, in any given direction, are constant. That is, the colors and their arrangement were made to look right to the average eye. Wave lengths were not considered at all.

On the other hand, *after the samples were prepared, they were very carefully calibrated by measurements on a spectrophotometer*, as well as on a colorimeter. This two-fold calibration, visual and instrumental or physical has great advantages which I shall point out in a moment.

I have already shown the difference between a "physical" and a visual arrangement in the scale of grays. Let me show the difference in the case of hue. Here are 20 colors at equal wave length steps. Do they look right? They surely do not[9]. To use such a circle to "measure" what we see would be like attempting to use a yard stick with some marks crowded together and other portions unmarked.

[6]The purpose of the three circles of varying hue can only be appreciated fully by seeing them in the colors as shown. The circles each showed the colors of the spectrum, in the usual order of the rainbow, with the reds and violets at the ends connected by the purples which are not in the rainbow or spectrum. These circles contrasted a grading of hue steps which look even to the eye with graduation by means of evenly spaced wave length steps, which look very uneven.

[7]A similar difference may be observed in the colors of the sunflower, a vivid color, and the buttercup, a grayer one.

[8]This book of charts may be seen in many libraries; for example the New York Public Library.

When you see how bad visually are the scales equally stepped physically, you may admit it and still ask, like a newspaper reporter: "So what?" Well, the importance of such facts is that many of the practical problems of industry are *visual problems*. That is, at least they are from the *consumer's* point of view. Thus, the ultimate consumer wants to know how much different a faded sample looks from the original dyed sample. He wants to know the size of the visual contrast between faded and unfaded samples. He is utterly indifferent to the change in the wave lengths and intensities of light reflected, unless these quickly tell him, in turn, the visual change. In the case of fastness to washing, it may be of interest to know that half of one dyestuff has been washed off, and only 40 per cent of a competing dye; but if the latter is duller because of a greater rate of change of brilliance with strength, the former may be preferred. Again, the primary interest is the visual contrast.

On the other hand, the dye manufacturer, in developing new dyes, wants to know physical facts. He is extremely fortunate to have an instrument with which he can measure accurately and rapidly the strengths of all water-soluble dyes. I shall return in a moment to other problems where the spectrophotometer is almost indispensable.

I hope I have shown enough to indicate that *what we see and what we measure are not always the same thing*, if indeed anyone ever supposed they were. Also, to indicate that sometimes our most profitable viewpoint is merely visual, at other times physical. I shall now show very briefly the relation between light measurements and color. By "color," I mean what we see. I do not use the word as a synonym for dyestuff.

I hope my explanation of the relation of light to color will be clear. I am reminded here of a remark about explanations. A famous scientist, Lord Kelvin, once remarked that it was still an unexplained fact why, when we push one end of a stick, the other end moves. It was Punch that retorted: "It is still more inexplicable that, when we kick one end of a man, the other end yells 'Ouch'."

Attempting such an explanation, let us think of light energy and color as cause and effect. Let me give an analogy to illustrate a similar relation of cause and effect. A pickaninny hears syncopated music; he starts to jig. Only syncopated music stimulates the jig; and a jig is always the response. This music is the cause; the jig, the effect. Scientists use the more accurate terms: "stimulus" and "response." The stimulus, light energy, evokes the

[9]Suppose we take the "wave length center of gravity" of the spectral curves as the "average wave length" of the reflected light, and show 16 colors differing by 19 millimicrons from color to color, so that we go from extreme spectral violet (400 units) to extreme spectral red (700 units); then add 4 purples to complete a circle. Here it is. Does it look right? There are 4 reds which cannot be distinguished from one another, and two more barely distinguishable. Then we have an orange and then a green-yellow. Yellows are completely absent. Then the steps get visually smaller again. Next there is a big step from blue-green to blue, and so on.

response, which we call color. Under identical conditions, a given light stimulus always evokes the identical color. If we change the conditions, the color may be different.

The point of all this is that there is no simple correspondence between the stimulus and the color. The outstanding example of this fact is the camouflage paints used in warfare. That scientific artist, or artistic scientist, Mr. Bittinger, of Washington, has prepared many pairs of paint stimuli which match, under a certain light; that is, give identical colors. Of course, on changing the light, the colors differ. He can thus make a German aeroplane look French. His next job will be to make a Communist look Fascist.

Permit me to be slightly inaccurate and use the word "light" instead of "stimulus." Then we may say that optical instruments measure light; they do not measure color. Not only do they not measure color, but it is only under very special circumstances that their readings can be interpreted as color. The great need is for the color-using industries, like the dye industry, to learn what these limitations are.

An outstanding case where the eye and the instrument do not seem to "see alike" is that of dark yellows or green-yellows. When we add black dye or pigment to yellow dye or pigment we get an olive, that is, almost a green. The light color and the dark color may have almost the same average or dominant wave length, yet one is nearly yellow, the other nearly green. A similar phenomenon has long been known to color scientists and is known by a high-brow name I shall not mention. When we take for example light of wave length 525 millimicrons, at a certain intensity it looks yellow-green. We do nothing whatever but take *less* of that light; it becomes green. How, then, can we correlate hue and wave length? This is a serious complication in attempting to interpret color from the spectral curves, or conversely. Roughly, if we *increase* intensity, all hues move *toward yellow or blue;* if we *decrease* intensity, they move *toward red, green or violet.*

When instruments and the human eye do not "see alike," some people assume that the instrument is right and the eye wrong, others that the eye is right and the instrument wrong. I insist that *both* are "right" when they are applied within correctly understood limitations. Both are right, but "see" correctly different things; and which to rely upon depends upon the particular type of problem. The "instrument right" point of view has been expressed by Professor Hardy of M.I.T. in his "Handbook of Colorimetry" and his "Physical Basis of Color Measurement" (J. Applied Physics, *8,* 233-38; 1937). The visual point of view is well expressed by Katz in his "The World of Color" (Rutledge; 1935). The outstanding exponent of the double point of view is Dr. Judd of the National Bureau of Standards. A point of view nearly the same is that of his colleague Dr. Gibson, and of Dr. Loyd Jones, of Eastman Kodak Co., in a preliminary report for the Colorimetry Committee of the Optical Society of America. I confess that my own point of view has been greatly influenced by long contact with these men, particularly with Dr. Judd, an international authority in Colorimetry.

The instrument measures the stimulus of color; not color. It deals with the syncopated music, not the pickaninny's jig. They are not the same thing. The light stimulus and color always correspond; but they do not always correspond in a simple way. We actually measure the stimulus and suppose we are measuring the perception, that is, color. If you will go to the Bureau of Standards, Dr. Judd will show you many demonstrations of the difference.

Judd continually stresses the fact that what we measure with instruments is the light which gives us what I shall call "hole colors." He shows how strikingly different these may be from the colors of surfaces, light paint panels or dyed yarn. We look through a hole in an instrument and see a color surrounded by a black field. We use only a few degrees at the center of the eye, where the sensitivity is enormously different from the outside of the eye. There are a number of other difficulties, theoretical as well as practical.

Judd, in a Bureau publication, has contrasted hole colors, such as we see in the spectrophotometer, with the "surface colors" which we commonly meet in practice, and has also distinguished other types. The trouble is that in practice *we most often see surface colors and are forced to measure hole colors.* We can readily prove the difference in certain cases. We can easily see the difference between the colors of this block of magnesia and polished silver. But if both are viewed under certain conditions of illumination they can not be distinguished. Similarly when measured; their surface colors are different, but when measured as hole colors in a particular way, they measure the same.

White paper in a room illuminated with yellow light is still seen as white; but if the same paper were seen through an aperture, that is, as a hole color, we certainly would call it yellow. As for the room itself, if evenly painted, we would call it the same color all over. Yet when different spots are looked at through a hole, they are seen to differ considerably. Also, an instrument would get differing measurements. In other words, practically we are interested in the surface color; we have to measure a hole color. Visually, the surface color is more complicated than the hole color; it is a perception which depends upon summing up in the brain information, some of which we do not get when peering through a hole in an instrument.

When you add to the difficulty of the difference between surface and hole colors, the errors due to different surrounding field, to seeing at one intensity and measuring at another, to using only the center of the eye instead of nearly all, to excluding the variations due to seeing and lighting at one angle only, and so on—then the wonder is that physical instruments ever give us anything at all similar to what we see. Very briefly, now, I shall show

what we do to make physical instruments measure something more like color.

Since color is the perception which we have when light illuminates a surface and is reflected to the eye, the first step is to adopt a standard illuminant and a standard eye to see. This was done by an international commission in 1931. Next we simplify the determination of the surface color by reducing it to a hole color with a particular angle of illumination and viewing and particular intensity. This is what we do when we use a spectrophotometer. We measure the intensity of the light reflected at each wave length in turn. With that dyeing of 0.25 per cent "Pontamine" Fast Red F we get this curve. It merely shows that much red light is reflected, very little green, and so on. We assume that the measurement somehow corresponds to our perception.

But does it? We have not only simplified the situation by measuring *one* stimulus to represent the whole set of colors we see at various angles, but have altered conditions by seeing the stimulus through a hole at a small angle and with black around it. Yet in spite of this the spectrophotometer often pictures the color with remarkable fidelity. Here is a dyeing of another lot of the dye. Two experienced testers decided that they were practically identical. Here are the two curves. (Only one line can be seen.) They lie on top of each other. I have a large number just as good.

Do they always do this? Well, here are the curves for a pair of Bittinger's camouflage paints which are nearly perfect matches when seen under an overcast sky; and here are two more: No. 1 is a bare trace yellower than No. 2![10] Evidently identical stimuli mean identical colors; but *not vice versa*: Matched colors can have very different stimuli. Therefore the questions are: If we get different curves, when are the colors alike; and if the stimuli are different, how much different do the colors look? Without explaining *why*, I shall very quickly tell *what* we do to answer these questions.

We refer to some experiments in which a large number of persons made a number of color matches, using only the colors seen in a spectroscope. With certain minor exceptions which I shall skip, we find that we can always match each spectrum color (of each wave length) in turn by suitable proportions of *three* primary lights. For example, we find that the average amounts of certain red, green and blue primary lights necessary to match spectrum lights of 460 and 600 millimicrons are these.

	Red	*Green*	*Blue*
460 millimicrons	.29	.06	1.67
600 millimicrons	1.06	.63	.00

If we do this with each wave length in turn we get similar figures which can be reduced to percentage coefficients. If we plot the equivalents we get the three curves shown[11]. These curves are merely a report of direct experimental data. For the particular conditions chosen, they give a relation between the light stimulus and the color. Between the syncopated music and the pickaninny's jig. The middle curve tells how light or how dark the color is; the three together what you dyers call its "shade."

These curves are just a shorthand statement of simple facts. You get out of them exactly what you put into them; no more, no less. They come from matches which a number of people saw as matches, on the average. They state that certain lights are equivalent to three mixed lights. They are records of matches. Therefore, they tell us when certain lights will be seen as matches; nothing more, nothing less.

But we *assume* that we can get more out of them. As I have said, we have chosen, by international agreement, a standard light source (really three). This one, shown through the courtesy of the Barkon-Frink Tube Lighting Corp. is like one standard for all practical purposes. We choose a standard eye to see. These curves are merely the record of that supposed average eye. We use them to convert light stimulus to color. What we need to do this is merely to combine for each wave length in turn the matching coefficients x, y and z with the light (R) reflected at the wave length. We can even allow easily for a light not the standard one if we know how much light energy (E) there is in the light at each wave length. This is mere simple arithmetic. Experiment shows that lights combine by addition. Therefore all we do is perform the multiplications indicated by

$$E \times R \times X$$

and so on, and add up. (More exactly, the processes are integrations.) The summed products for the three primaries are taken separately and expressed as fractions of their total.

In this way we get three numbers. These three numbers are known as the trichromatic coefficients of the color. Thus two of the colors of the United States flag are legally defined as

	x	*y*	*z*	*R*
Red	.56	.32	.12	.073
Blue	.28	.26	.46	.025

where x, y and z refer to the relative amounts of reddish, greenish and bluish international primary lights. They constitute the trichromatic analysis of the color. The last figure (R) is simply the percentage of the standard light which is reflected. Any one wishing to sell flag bunting to the army or navy must obtain this trichromatic analysis.

The same trichromatic analysis can be obtained directly by means of a colorimeter. The method simply consists in matching the sample with a mixture of the three primary lights of the colorimeter. For example, the 400-odd colors of the Munsell "Book of Color" were all calibrated on a Guild trichromatic colorimeter. They were also calibrated on a spectrophotometer. The important thing is that the colorimeter measurements were made by two girls whose vision was definitely and systematically

[10] The curves of the nearly perfect matches were utterly different.
[11] See the Hardy *Handbook of Colorimetry*.

different. The writer's determinations fell in between. But the average of the readings agreed very well indeed with the analysis with the spectrophotometer. Of course, the colorimeter had a set of primaries different from the three international primaries; but conversion from one set to the other is a mere matter of slide-rule arithmetic after having the experimental data on the matches with the primaries published in 1931 by the international commission.

This brings out the most important difference between determinations with a spectrophotometer and with a colorimeter. The former is practically independent of the personal element; colorimeter readings depend on the eye of the observer. A color-blind man can use not only Hardy's automatic spectrophotometer (built by General Electric) but a visual one as well. On the other hand, the great advantage of the colorimeter is its speed. It took about two minutes for a match in the Guild colorimeter. The Hardy spectrophotometer of course does as well or better. But the calculations necessary with any spectrophotometer take many times as long as is necessary with the Guild colorimeter. The two girls I refer to made the calculations on the Munsell colors with slide rules in one minute, and this calculation not only included conversion from the instrument set of primary lights to the standard primaries, but also included a calculation which partly corrected for the differences in the vision of the two girls.

Because of this advantage of speed, the cheapness and the directness of the trichromatic colorimeter, British practice has preferred measurements with a colorimeter. In America, the spectrophotometer has been preferred because of its precision, its fundamental nature and practical freedom from personal variations. In spite of its disadvantages, I would like to suggest two or three practical problems in dyeing which could be very profitably studied with the speedy, cheap, simple colorimeter. These are: (1) A study of the chroming process, that is, of the exact conditions of time, temperature and concentration of chrome necessary to secure maximum shade (hue) change with minimum dulling; (2) a similar study of the soaping and oxidation of vat dyes; (3) similar studies of various after-treatments of dyeings. For such problems, where it is chiefly comparative results that are wanted, it really doesn't matter much if the observer's vision is somewhat abnormal. Also, he will usually not need to convert readings from colorimeter primaries to expression in terms of standard primaries.

Many of the uses of the spectrophotometer in the dye industry were thoroughly treated by your Program Committee chairman in 1930. Nearly everything he said then is still true today; and I advise you to re-read Dr. Draves' paper. It so impressed me that, at my instigation, he repeated it before the Optical Society of America in 1931; and you may find his paper either in its journal or the AMERICAN DYESTUFF REPORTER. We have both referred to the value of routine dyestuff strength measurements with a spectrophotometer. It is invaluable in the identification of dyes, for example, competitive types; it can be extended to the identification of colorless intermediates. A spectral curve would be a perfect way to specify a dye for patent purposes. Dr. Shelton, when at Cheney Brothers, used it to check up on purchased lots of dye and to improve the reproducibility of dyeings. He not only used it to control the quality of purchased dyes, but to check up on the severity or laxity of various inspectors of matches. It is often a fine referee. It is extremely valuable in measuring the substantivities of various dyes, by measuring the percentage exhaust of the dyebath.

I will not recommend the spectrophotometer for matching in the dyestuff industry, although Mr. Carl Foss of International Printing Ink says that the Hardy spectrophotometer has so simplified their matching that they can now concentrate on the really hard and important problems. I have pointed out how proper spectral analysis can give a complete match, one that will stay put for any light, for any eye. When matches are bad, the spectrophotometer, because it is analytical in a way in which the eye is not, will tell *why* it is bad. It will answer: Is the match poor because of hue or because of lightness? Is too much red or too much orange light reflected? In such cases, the time is short, because computations do not have to be made after the measurements.

A spectrophotometer may save time by preventing the impossible. I once had a case where two minutes with the spectrophotometer would have saved many days of work which had been actually spent trying to accomplish the impossible. Chemists were trying, for esthetic reasons, to dye a liquid violet, when there are already present a chemical which had to be there for chemical reasons, that completely absorbed violet light. The spectrophotometer will often prevent trying such impossible things. Similarly, if we have spectral curves of each dyestuff, only once for all, we can save immeasurable time not trying to use dyes which simply will not work.

A type of problem which is one of analysis of light, rather than color, calls for the spectrophotometer. Some years ago there came up the problem of specification of the dyed gelatin filters used for stage lighting. Of course, the stage director wants the right color on the stage; but the problem of the man who dyes the gelatin is not the color of the gelatin; it is how much light of various wave lengths is transmitted. That is, of two filters which look exactly alike one may be worthless for the particular stage set, while the other delivers the correct light. Here the final solution was to make the lot numbers of the filters as sold specify the amount of light transmitted in various bands of the spectrum. This is a light analysis problem, not a purely visual one. Very similar considerations apply in the production of dyes for photographic filters.

A very important and practical use of the spectrophotometer is the establishment of permanent standards. In the paint, pigment and lake industry you hear a lot about the "drift" of color standards. A fundamental paint stand-

ard may not stay put for several years. A spectral curve of the standard is permanent for at least a century. Perhaps permanence of dye standards is not so important. But it is doubtful whether even pure dry powdered dyes remain permanent for several years, and there may come a time when we will want our standards to remain permanent at least for a few years. Meanwhile, too, it is worth noting that several thousand spectral curves can be filed in a cubic foot of space. Think of the space it requires to file a few pounds each of a thousand standard dyes.

Finally, let me mention some problems where instruments are *not* to be recommended. First, I shall consider the problem of tolerances, or allowable departures in matches. Suppose we have thousands of dollars at stake on a government job of dyed flag bunting or a pink bond paper. When is it an acceptable match? This is what I have called a purely visual problem. It is a matter of visual contrast; contrast of sample and standard. Suppose the government decides that a plus or minus tolerance of ten units is acceptable. The unit contrast is to be the least difference the average eye can see, under certain conditions. I have shown that spectral curve differences will not do. For any given curve, there are theoretically an infinite number of curves giving ten units difference. The government can't specify the infinite number. They *can* specify trichromatic coefficient and reflectance limits. But to do this they have to know the correspondence between trichromatic analysis and color contrast. If we graph the trichromatic coefficients of the spectrum we get a so-called "color triangle" which does give some sort of a picture of color differences. It would be a perfect picture if a constant difference at any place on the chart in any direction always meant the same color contrast. But it doesn't; it is somewhat warped. Judd has shown that with a different set of primaries we get a better picture. It's merely again a matter of simple arithmetic to convert from one set to the other; because both are based on the same set of matches. But even this isn't enough! Trichromatic analyses ignore reflectances. For several years, several of us have worked on ways of combining trichromatic data and reflectance to compute how different two colors look. Judd finally has a formula which appears to work very well. He has very recently applied it very successfully to grading the whiteness of paper stocks from measurements. The highest reflecting paper doesn't always command the best price.

Therefore, to let an instrument act as referee, we first have to make measurements, say at 30 wave lengths. We do a lot of multiplying, adding and dividing to get a trichromatic analysis. Then we calculate to the basis of Judd's primaries. Then we use Judd's formula, which takes account even of background and gloss, and compute some more. When we are through we *may* know how different the sample is from the standard; whether it meets the government tolerance. Even Judd's formula isn't perfect. Part of the reason, I think is because the international data is based upon *matches,* and we are stretching them to apply to *differences;* also, the data were obtained from *hole* colors, and we apply them to the colors of *surfaces.* After all this do you wonder that I recommend avoiding the spectrophotometer for deciding how good or how bad a match is in ordinary practice? It is different wth thousands at stake.

A very smilar situation applies in rating the color differences obtained in fastness tests. The thing we really want to know is the color contrast of faded and unfaded sample. This is a purely visual problem. Over a year ago, at a color conference at M.I.T., organized by Professor Hardy, I spent an hour showing not only this, but also that the use of a spectrophotometer would be impractical even if it perfectly measured the color difference. I have here something I regard as a much better solution of this problem. It is far from perfect; but it will give a more definite and accurate meaning to our "trace," "noticeable" or "considerable" difference. I have here 75 pairs of colors. The two members of each pair differ always by a constant difference. This constant contrast is always between the second and third steps on the usual 5-step fastness scale, which is a critical point. Almost anyone can tell whether a test difference is a little more or a little less when seeing also a comparison standard; and, with a little experience, can say quite consistently that it is twice or half the difference. To make comparisons much easier, the 75 pairs were carefully spaced in the three dimensions of the color warehouse, so that we always have a pair nearly like the test pair. Such a selection can only be made with a system logically arranged in the way I have outlined. When these charts are perfected I think we will not have one man's rating "a trace" today and "noticeable" tomorrow; or another man's "considerable" at the same time. Personal variations will still be present; but I have been astonished how well different persons agree.

I shall close by merely listing a few other purely visual problems, ones which can be handled often with the aid of the Munsell colors, or something similar. We state in sales literature that the "shade goes redder in artificial light." Why not say 3 steps or 10 steps redder? Getting such data is extremely simple. We say in reports that a 4 ounce dyeing is redder than a 2 pound dyeing of the same dye. Why not state exactly how many steps redder? It is bluer on silk than on wool. Why not say it is only 6 steps, while your competitors' is 10 steps bluer? If nothing else, you might save thousands of dollars in the costs of sample books and inter-laboratory strength cards. One of these days Lanital or some other new fiber may follow rayon and acetate silk on the market. Wouldn't it be simpler to send a thousand customers a list of figures than to send them new sample cards for your whole line of dyes?

There's no reason why you shouldn't write color the way you write music. When you do it filing the formulas of mixes will be enormously simplified. You can telegraph a few symbols to your San Francisco office, or cable Hong Kong. Spectral curves would be hard to transmit,

though they would take less time than dyeings. Finally, let me list an important purely visual problem, though one which may not have occurred to you. A large dye manufacturer may prepare 30 new dyes a day, possibly 9,000 in a year. Someone *may* remember that someone six years ago prepared a dye of a given type with a desired color. But he may not remember. The indexing and filing of colors for quick reference is an enormous problem. Ignoring the problem of storing thousands of dyes or dyeings, think of the job of locating a particular color, even if they are stored in sections, as reds, oranges, browns and so on. I recommend that you file instead three simple numbers for each dye. These numbers will be index tabs. They can be obtained in a couple of minutes, with considerable accuracy. You can do this after you have learned how to segregate purely visual problems from physical stimulus problems. After you have distinguished the pickaninnies' jig from the syncopated music. Therefore also when to flirt with Circe and when to court Lorelei. And this, let me remind you, was my thesis. Also, keep both ladies in sight; and be ready to leave either one flat.

In Defense of "Lanital"*

HECTOR C. BORGHETTY†

YOUR chairman has entitled this talk, In Defense of Lanital for a reason which is quite obvious—Lanital needs defending. Its birth, as a commercial textile fiber, dates back two years, but as you all know these two years have been hectic with criticism. Few good words in its behalf have ever appeared in English or American technical journals. A lone note, not of criticism, came from our northern neighbor, Mr. Paul LaRose, of the Ottawa Research Council. He was not adverse to the appearance on the market of a new synthetic fiber of protein origin.

While taking its defense this evening, let us try and consider some of the items which caused the stampede of criticism. Lanital means "Italwool", but unfortunately it has been introduced to the English speaking world as artificial wool, and investigators sought to prove that Lanital was not identical to wool. In proving this, they forgot that Lanital might have some possibilities of its own. It is not artificial wool, and furthermore nobody wants to produce wool artificially. It is bad enough for the sheep to take six months to grow a coat of hair without expecting the scientific world to duplicate the process.

I happen to have grown up in one of the worlds largest sheep raising countries, Australia, and to me, sheep are not very efficient except in collecting dirt, which accounts sometimes for up to 80 per cent of the weight of the wool.

The present administration in Washington is far more careful in introducing new brain children. They say A.A.A.—X.Y.Z. etc., and let you find out for yourself what they are.

I would be inclined to classify Lanital as a rayon having a chemical constitution similar to that of the animal fibers. Chemically, in fact, it is almost identical to wool and silk, while physically, it greatly resembles the various rayons. We call acetate a rayon, why not then, call artificial wool protein rayon, or better still, Lanital rayon?

A second item which militated against Lanital was its period of introduction. The year 1935 saw the beginning of the Ethiopian War and the subsequent experiment of "economic sanctions". Lanital was not ready to be put on the market in those days, but the Italians had to show something. They had to prove that they were commercially independent in the textile world; they had rayon and now they wanted to prove that they had wood.

Meanwhile, a testing laboratory in Bradford, England was asked to give a report on whether Lanital was equal to wool and quite naturally reported that the two were not identical. A college professor, getting his science and his politics mixed, wrote an article which presented the new fiber as a fake. This started the stampede which influenced us here in America.

The real difficulties were never brought forward. Lanital, like wool, is slightly yellowish due probably to the sulfur present in the molecule. Its heat-conserving property is not by any means equal to that of wool but the information obtained recently concerning thermal-conductivity will shed a lot of light on the subject and enable the manufacturer to improve this drawback. There is really one great disadvantage about Lanital, but nobody has ever mentionel it. If wetted out and allowed to stand for a certain time in a dark place, it would become quite putrid. Nobody worried about this. It didn't look like wool, and critics were not interested in finding out more about it.

Lanital has gone a long way since then and today it is necessary to find out more about this fiber, because shortly we will have to start looking for it in the fabrics we are processing. Particularly nowadays, with the impetus that spun rayon has acquired, Lanital promises to play an important role as a component in mixed fabrics. When its price is lowered it will be economical in wool mixtures.

To all of us who have witnessed the spectacular growth of rayon, the arrival of Lanital is welcome because we

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are well versed on the prime advantages of synthetic fibers, in regards to uniformity, and complete absence of impurities and foreign matters.

When preparing rayon fabrics for dyeing, the only impurities to remove are those which have been added to facilitate weaving. This will also be the case with Lanital fabrics.

Once costs of production are lowered sufficiently Lanital will find its way quickly into mixtures with wool or spun rayon, giving in the first instance an economical advantage and in the latter case, acting as a beautifying component.

It is not identical to wool, but there is a great similarity in the chemical formulae of casein and wool. In fact the carbon, hydrogen, oxygen and nitrogen contents are almost identical in both wool and Lanital. The sulfur content is much higher in wool, being 3.6; that of Lanital is only 0.7. The phosphorus content of Lanital is 0.8, and there is none present in wool.

When Lanital burns it gives the well known burnt wool odor and leaves a fine powdery ash; due to excessive mineral content which should be reduced by the manufacturers.

The dyeing properties of Lanital depend largely on its amphoteric behavior, which is identical to that of wool; and on its ability to swell in water. It dyes readily with dyestuffs having acid or basic characteristics, while it has a great affinity for direct dyes. Its diameter increases when wet, and in the presence of alkalis or acid this is accentuated.

Dyeing operations are greatly simplified with Lanital because it dyes much more readily and evenly than wool. Large quantities of acid are not necessary, and inorganic acids can be omitted, because of the ability of Lanital to assume a plastic condition in a warm water bath. This property of Lanital gives a contrary effect in regard to its retention of dyestuffs. Dyes of good fastness to washing on wool are oftentimes very poor on rayon, and therefore it is well to use dyestuffs of outstanding wash fastness if good results are desired. These, though generally speaking, not of good leveling ability on wool, are very easy to dye on Lanital because of its excellent colloidal condition. Dyeing temperatures above 170° F. are not necessary; otherwise the present methods used for wool are perfectly suitable for Lanital. It is not advisable, however, to dry Lanital at high temperatures because of the ever present danger of tendering. Lanital should not be dried above 105° C. All the types of Lanital prior to November 1936 are not very strong, whereas the types after that are quite good.

Now we have all seen in the Daily News Record that Lanital is being taken off the market. If this were true, the Italians would not say it. I have a confirmation of this fact in a cablegram.

Lanital is prepared from skimmed milk, after the butter has been extracted. I cannot give exact figures, but approximately about 25 gallons of milk give about 10 lbs. of butter and about 4 or 5 lbs. of Lanital fiber, which means about 12 or 13 yards of ladies wear construction. Although the source of supply of Lanital is casein, prepared from coagulated skimmed milk, it is quite possible that some day we might find another source of protein which will serve the purpose and we won't have to rely on the cow. The casein is dissolved and the solution is forced through appropriate spinnerettes and coagulated in a sulfuric acid bath. It is then passed through a formaldehyde bath to fix the casein. It is safe to say that a gallon of skim milk gives about a yard of fabric (four yards to the pound) and at the same time you get a third of a pound of butter.

Lanital fiber can be produced in any fineness and any length. However, the average length is about 4½ inches and the average fineness is about 23 microns, which corresponds to about a 56's; the 56's Lanital is much more uniform than the 56's wool; it can be spun as a 64's.

Its diameter is extremely regular and it thus has an advantage over wool which varies with its location on the sheep's back, the season of the year during growth and the health of the sheep. If the sheep is sick, there is a change in the size of the fiber. Lanital has none of those drawbacks. We find Lanital both in spun form and in filament form. Pure Lanital fabrics resemble wool and it is quite difficult to find differences between Lanital and wool in appearance.

Pure Lanital fibers can be distinguished qualitatively from wool by treatment with a 10 per cent solution of caustic soda at room temperature for a few minutes, then washing and immersing in a 1 per cent methylene blue solution and rinsing. It becomes intensely colored in blue, while wool is only slightly stained greenish-blue by this method. The swelling action of the caustic solution can be also duplicated by treatment with 1 per cent sulfuric acid for 10 minutes at the boil.

A chemical method of quantitative analysis to differentiate Lanital in wool mixture is based on the much higher resistance of Lanital to strong alkali, and is outlined in an article by Mr. Paul LaRose in the September 20th issue of the DYESTUFF REPORTER. Mr. LaRose's article carried a 12.3 factor. This method was developed by Da Schio and takes the place of the original method proposed by R. Vaglio, which cannot be used today. The new method consists in immersing a desized sample of fabric (Lanital-wool) of known moisture content, into a 20 per cent soda solution at 30° C. (somewhat above room temperature) for 3 hours, and agitating from time to time. The caustic dissolves the wool completely and also 9.5 per cent of the Lanital content. Rinse well, acidify with acetic acid, rinse and dry. The Lanital content is therefore figured as follows:

. inal bone dry weight by $\frac{100}{90.5}$ = actual dry Lanital content.

If the temperature (30° C.) and the time (3 hours)

are not maintained, the 9.5 factor cannot be used, because at higher temperatures and concentration of alkali, and over longer periods, a much larger percentage of Lanital passes into solution.

This method will serve all practical purposes. Obviously, it is not a strictly scientific procedure but rather an empirical test. Furthermore, Lanital itself is subject to constant improvement and will tend quickly to render obsolete such methods of determination.

The average regain of Lanital at standard conditions of 65 per cent relative humidity and 70° F. is 15.2 per cent, in the latest types.

Lanital can be quantitatively determined in mixtures of cotton or other vegetable fibers by treatment with caustic soda. In this case, the operation is carried out as is customary for silk and wool determinations. If rayon is present, however, the caustic soda treatment is somewhat too strenuous, and concentrated sulfuric acid (58° Bé) at room temperature for a period of two hours is employed. This reagent dissolves the rayon without hardly affecting the Lanital.

When viewed under the microscope, it is almost impossible to tell Lanital from rayon. Its appearance in "tops" is similar to that of wool, although it packs more heavily. It is somewhat more lustrous. Under the microscope Lanital is smooth and cylindrical, but has the longitudinal streaks common to rayon. Its cross section is regular and rather round, but shows the toothlike indentation caused by the coagulation. It is very easy to distinguish the natural from the synthetic produce microscopically on account of the total lack of scaliness and crimp.

Instead of defending Lanital it might seem as though I am selling it. All I want to do is to take the defense of the fiber, because even though I don't think that Lanital is a perfect product, I really feel that it is a stepping stone toward a much finer fiber, and that some day we are going to make use of it. It will be produced and controlled by a very scientific industry. In other words, we shall have people—rayon people—manufacturing it. They always find ways and means of improving their products. Rayon was considered a poor thing ten or eleven years ago, but today we wouldn't say that. Lanital has not done so badly when we consider its short period of life.

DISCUSSION

Q. Is Lanital made in this country?

A. It is not, so far as I know, made in commercial quantities.

Q. What about its felting properties?

A. Quite important. It does not felt at all. It just seems to go all over the place, but in the presence of wool it does not hinder the felting action of wool—in fact it facilitates it.

Q. Will it stand carbonizing?

A. Yes. In fact, a method of analysis is based on the fact that it will stand sulfuric acid treatment the same as wool will. There is however a weakening effect.

Q. Can you make good unions with Lanital wool blends?

A. Yes—in fact, I have a piece of a soldiers uniform here containing 35 per cent Lanital and 65 per cent wool.

Q. In what form must it be dyed?

A. It should be dyed in raw stock in order to obtain best results. It would be difficult to obtain even shade on two fibers, because Lanital takes color so quickly. You could boil Lanital with water and acid as you would wool without tendering, provided the acid is not an inorganic acid. It is all right to go to the boil, although the fiber will become a little more tender. Lanital loses about 60 per cent of its strength, when wet, but regains it when dry.

Q. What is the comparison of the light fastness of the same colors of wool, and the perspiration fastness, as compared to Lanital?

A. Light fastness identical, but the perspiration fastness is lower on Lanital.

Q. Can you dye Lanital better with direct colors or with acid colors?

A. Dyes very well with direct colors or with acid colors. With acid colors it often dyes well even without the acid being present.

Q. How is it with chrome colors?

A. Chrome colors much as on wool.

Q. Do you prefer union or acid bath?

A. Acid bath.

Q. What is the price of Lanital as compared to wool?

A. There has been very little information given out about that, but the last price was about $1.10 per pound for Lanital. On the other side I think it is selling much lower, around 60c-70c per lb.

Q. Dr. Eure at the opening of the Mellon Institute asked "what are the wearing properties of the uniforms worn by the soldiers." Did they wear well? He understood that the uniforms were made out of Lanital straight.

A. No uniforms are made out of straight Lanital. Percentage is mostly 50 per cent. It is more economical for them to use Lanital instead of straight wool. The uniforms would not have worn satisfactorily if made out of straight Lanital.

Q. Will moths eat Lanital?

A. Moths will not eat Lanital. Dr. Harris checked this point and found that it was probably due to the absence of the cystine linkage.

Q. What is its fastness to washing and soaping?

A. Fastness to washing always low and to water same. Fastness is not as good as would be expected.

Q. Is milk the only source of casein they have done anything with?

A. It is the only source suitable for textile use at present.

Q. Can you suggest any practical method of dyeing Lanital?

A. Do not use too high a temperature because of the danger of tendering. In the presence of acids it dyes readily. It depends on the proper selection of dyestuffs and temperatures. You would have to use dyestuffs of outstanding wash fastness.

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MILL LABORATORIES

WE do not have nor have we seen any figures on the subject but it is our impression that there are more and more mills that have established laboratories in the last few years and are employing one or more chemists to run them. It is becoming increasingly necessary for the textile plant to maintain a well equipped laboratory with men capable of performing both physical and chemical tests. This has come about partly through consumer consciousness as to what quality of materials to expect, thus leading to rather rigid demands upon large mail order houses and department stores and they in turn demand from the mills deliveries of definite specifications. Furthermore very definite specifications are being set up through certain U. S. Governmental agencies such as the National Bureau of Standards and the Federal Trade Commission, which in many instances must be complied with, especially if dealing with the government.

In addition to testing outgoing merchandise to see that it checks with certain specifications, the mill laboratory has assumed considerable importance in checking incoming materials to see that certain standards are maintained. Further, the mill laboratory, in working with the dyer and finisher, has become an important factor in the development of new processes, lowering of costs, selection of the proper products for dyeing and finishing and application of new principles of dyeing and finishing. The mill laboratory also acts as the "go between" in the interpretation of research results of outside research agencies to fit these results to the routine and practice of a particular mill. The mill laboratory is an important source of men qualified to serve upon various committees of research organizations, contributing a viewpoint that is vital and necessary to a sound research program that will be of benefit to a textile mill. A textile mill that has no laboratory can make a very wise investment if it will hire one or more capable men and equip a laboratory in which it is possible to carry on sound chemical and physical testing.

COMING ISSUES

TWO important issues of the REPORTER will make their appearance in April. The first will be the Quarterly Research Number which will appear on April 4th and the second will be the Knitting Arts Exhibition Number which appears on April 18th.

The quarterly research numbers were inaugurated during 1937, the first of these quarterly numbers appearing on July 26th. It was stated at the time that the purpose of the plan was to bring together in one issue reports on research projects and other experimental work in which the Research Committee of the A.A.T.C.C. is engaged which, it was hoped, would be of convenience to our readers inasmuch as the more important publications of the Research Committee would appear at definite intervals and would be concentrated during the year in the four quarterly numbers. Judging by the requests which we have had for additional copies of these issues, even before publication, the idea has been well received by our readers and we interpret this to mean that they have found the issues of particular value to them. The first quarterly research number for 1938 appeared on January 10th and, after the April 4th number, additional numbers will appear on July 11th and October 3rd.

For several years on the occasion of the annual Knitting Arts Exhibition in Philadelphia, we have issued a number dealing in particular with the dyeing and finishing of knit goods and hosiery and containing other articles of interest to the hosiery dyer and chemist. We will, as usual, publish on April 18th an issue containing special articles on the wet processing of hosiery and knit goods in conjunction with the Thirty-fourth Annual Knitting Arts Exhibition to be held in Philadelphia at the Commercial Museum during the week of April 25th. In addition this issue will contain complete descriptions of those exhibits in which the readers of the REPORTER will have a particular interest.

NEXT MONTH

Quarterly Research Number
April 4th

Knitting Arts Exhibition Number
April 18th

Physical and Chemical

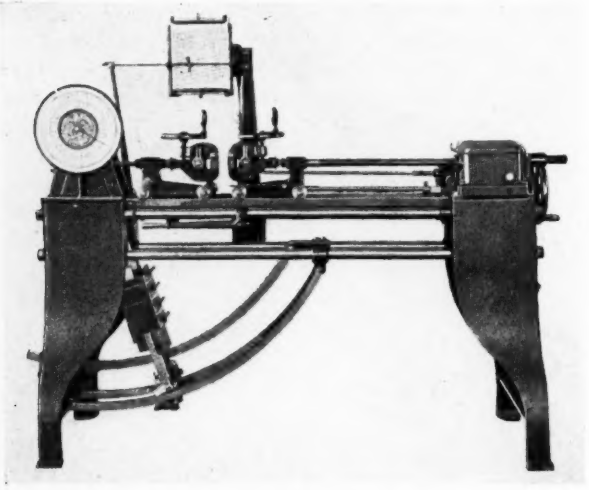
Textile Testing

(Continued from page 146)

6. Moscrop single strand tester—designed to carry out a number of single strand tests at once, recording the results on a chart; not as accurate as the ordinary single strand tester but good for showing variations in strength.

7. Fiber strength testers of the pendulum type are very low capacity machines.

Before use, the strength tester should be zeroed and calibrated. It is zeroed by lifting the ratchet and letting the pendulum hang vertically, the pointer is then set to zero on the scale. To calibrate, a weight is rested on the lower jaw and attached by a wire or cord to the upper jaw, the machine is started and the weight comes onto the upper jaw at the same rate of speed as the stress on the specimen. The scale should be calibrated at a number of points on its range and a correction table or chart prepared.



Courtesy, Henry L. Scott Co.

Fig. 36—Pendulum Strength Tester—Horizontal Type, with Autographic Recorder.

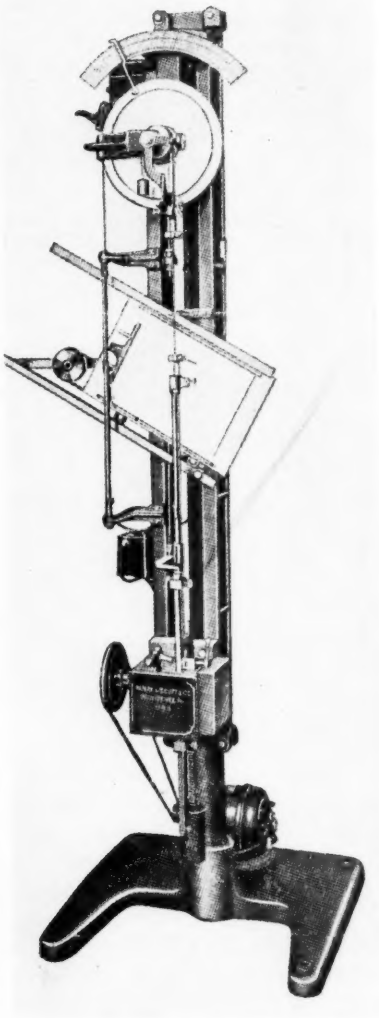


Fig. 37—Pendulum Single Strand Tester with Autographic Recorder.

Courtesy, Henry L. Scott Co.

Assuming the samples to be tested at a constant relative humidity and temperature, the variables due to the machine itself which affect the apparent strength of the specimen are:

1. Friction and inertia errors—these are a function of the construction and care of the machine and have been shown by Haven to be not over 2½ per cent at the most. If the machine is well made and kept cleaned and oiled this error is negligible and at any rate would be a constant.

2. Form of the jaws—these should be so made as to avoid cutting of the specimen. The standard types of jaws will be taken up later.

3. Gauge length or distance between jaws—it has been shown that breakage of textile materials is mostly due to slippage of the fibers. If the gauge length is increased, more slippage can occur and the breaking strength will be less. Another factor is the fact that in a longer length of specimen there is more chance of a weak spot occurring and giving a lower breaking strength. Still another reason is that a longer gauge length means more stretch of the specimen so that a longer time is required to reach the breaking point; the rate of loading is therefore slower and a decrease in strength results. The following table gives the relative breaking strength for different materials at three gauge lengths; this table is for illustration only, and not for correcting results from one gauge length to another.

	Gauge Lengths		
	1 *Inch*	3 *Inches*	6 *Inches*
Rayon yarn	100	100	93
Silk yarn	111	100	93
Worsted yarn	125	100	88
Cotton yarn	111	100	92

4. Speed of the lower jaw—the slower the lower jaw moves, the more time is given for the fibers to slip and the lower the strength reading. Standard speeds will be given later. The following table will illustrate the effect of jaw speed on the relative strengths of some samples.

	Jaw Speeds		
	6 *Inches/ Min.*	12 *Inches/ Min.*	18-20 *Inches/ Min.*
Rayon yarn	97	100	104
Silk yarn	90	100	103
Worsted yarn	97	100	103
Cotton yarn	99	100	104
Cotton duck	99	100	102
Wool felt	97	100	101

5. Capacity of the strength testing machine—a fabric of low strength on a high capacity machine gives a high breaking strength because the time required to break the sample is short and therefore less slippage of fibers can occur. The following illustrative table gives the effect on a cotton cloth.

Machine Capacity	*Strength —Pounds*	*Time to Break —Seconds*	*Relative Strength*
150 lbs.	65.8	5.25	100
300 lbs.	67.8	3.85	103
400 lbs.	69.5	3.10	106
800 lbs.	75.4	2.55	114

It is generally specified that the maximum swing of the pendulum shall be not over 45°, it is also specified that the lower 20 per cent of the capacity (first 9° of swing) shall not be used; this often limits the machine which may be used on a given sample to one particular capacity but often also several machines might be used and would give different results.

6. Stretch of the specimen—a specimen with a large amount of stretch takes up the load slowly and gives a lower breaking strength.

It will be noted that numbers 4,5,6 and part of number 3 above are all dependent upon the time of load application or rate of loading and that these variables would be eliminated if the rate of loading were constant, the method of doing this will be discussed later under another heading.

The A.S.T.M. has laid down the following general rules in regard to clamps or jaws of strength testing machines:

1. The jaws shall have metallic gripping surfaces which are smooth, flat, and parallel.

2. The dimension of the clamp parallel to the direction of application of the load shall be one inch and in the direction perpendicular to the load shall be as specified for each test.

3. All edges which might cause a cutting action on the specimen shall be rounded off to a radius of not over 1/64 of an inch.

4. One clamp of each pair shall be fixed in position, the other shall be hinged or swivelled and the clamping action may be by either screw or cam.

Cloth samples may be tested in one of three ways:

1. By strip samples
   a. Cut strip
   b. Ravelled strip
2. By grab samples

Cut strip samples are prepared very simply by cutting specimens 1 inch wide and 6 to 7 inches long. These samples have the disadvantage that the lengthwise yarns at the edge tend to spring away from the center yarns and, having a large amount of crimp, do not take up their share of the load; cut strip samples therefore are used only on heavily sized or coated fabrics and not on ordinary fabrics. Ravelled strip samples are cut out 6 to 7 inches long and 1¼ inches wide if there are 50 or more yarns per inch, or 1½ inches wide if less than 50 yarns per inch. After cutting out, the specimens are ravelled down to 1 inch wide by removing approximately the same number of lengthwise yarns from each side; this is done so that the edge yarns may be supported and held in place by the cross yarns almost as firmly as the middle lengthwise yarns. In the case of both types of strip samples, the clamps used are 1½ inches or more wide, the gauge length is 3 inches, and the speed of the lower jaw is 12 ± ½ inches per minute. The results of specimens which slip in the jaws or break at the edge of the jaws should be discarded; for this reason, it is a good idea to always prepare a few more samples than are actually called for in the test specifications.

Grab test specimens are cut out 4 inches wide and 6 inches long, with the longer dimension in the direction of the yarns to be tested. The front clamps should be 1 inch wide and the back clamps 2 inches wide, the gauge length should be 3 inches, and the speed of the lower jaw should be 12 ± ½ inches per minute. In this case also, the results of specimens which slip or break at the jaws should be discarded. An effort must be made to grip the same yarns by both upper and lower jaws, to facilitate this a line may be drawn along one thread and the sides of the jaws placed on this line.

In cutting out samples of fabric for test, at least 5 tests must be made on the warp and 5 on the filling; samples should be taken as in Figure 39. If 10 samples are desired (much better than only 5 samples) the sampling is repeated on the other side of the center line of the cloth and further along the piece.

[1]Strip tests are more reliable and accurate than grab tests but grab tests are much faster to carry out and are especially good on fairly open fabrics. Strip test results are directly proportional to the number of yarns in the width and therefore are a good test of the component yarns; grab test results do not show as good a relationship between strength and number of yarns gripped but are satisfactory for ordinary testing. The A.S.T.M. uses

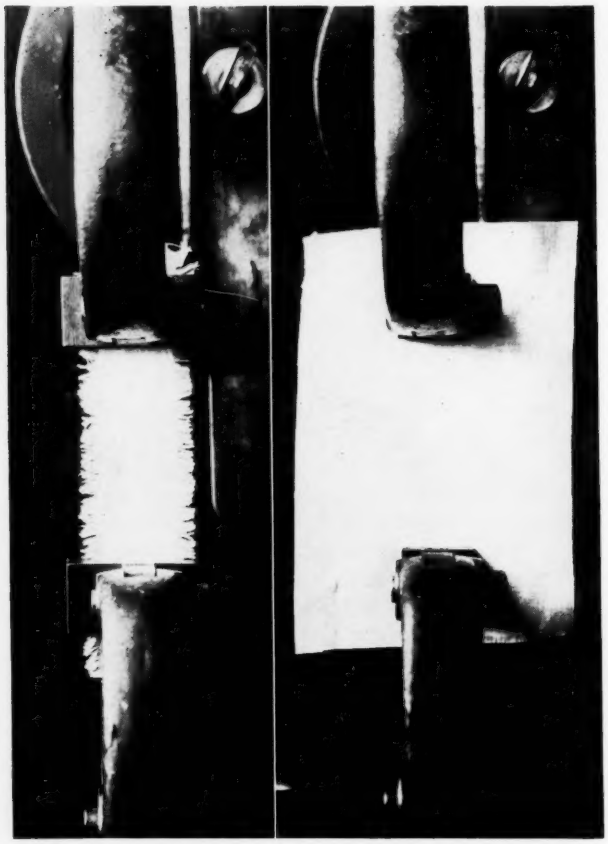


Fig. 38—Ravelled Strip Sample and Grab Sample in Jaws of Strength Testing Machine.

grab tests on all fabrics for control work, but the strip tests are better for research work. An approximate relationship between strip and grab tests for fabrics under 20 ounces per square yard is

$$\frac{\text{grab strength}}{\text{strip strength}} = \frac{9}{8}$$

The higher results on the grab strength are due to the reinforcing effect of the side yarns not directly gripped by the jaws.

Woven tapes are tested in full width with the same gauge length and jaw speed as above; the filling is not generally tested.

Yarns are tested in one of the following ways:

1. Skein test
2. Single strand test
3. Serigraph test
   a. Haven method
   b. Multiple strand method of the Bureau of Standards
   c. A.S.T.M. method

The selection of the method to use in any particular case depends on the purpose of the test, each method having certain advantages and disadvantages. The A.S.T.M. specifies the methods to be used as follows:

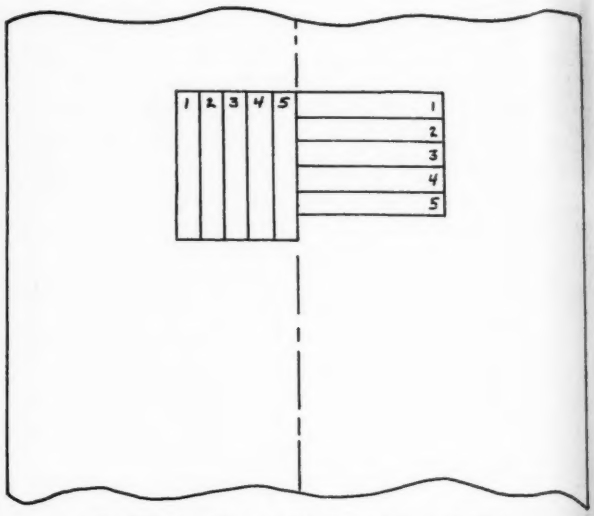


Fig. 39—Sampling of Fabric for Strength Tests

	Preferred method	Alternate method
Cotton yarns	Single strand	Skein
Woolen and worsted yarns	Skein	Single strand
Rayon yarns	Serigraph	Single strand

For the skein test, the yarn is wound on a 1½ yard reel; the yarn is drawn from the top of a bobbin, cop, cone, or small flanged spool and drawn from the side of a parallel tube or large flanged spool; the ends of the skein are tied in a square knot. In the case of a woolen or worsted yarn, a 120 yard skein is wound; in the case of cotton yarns, the length of the skein depends upon the number of ends in the package.

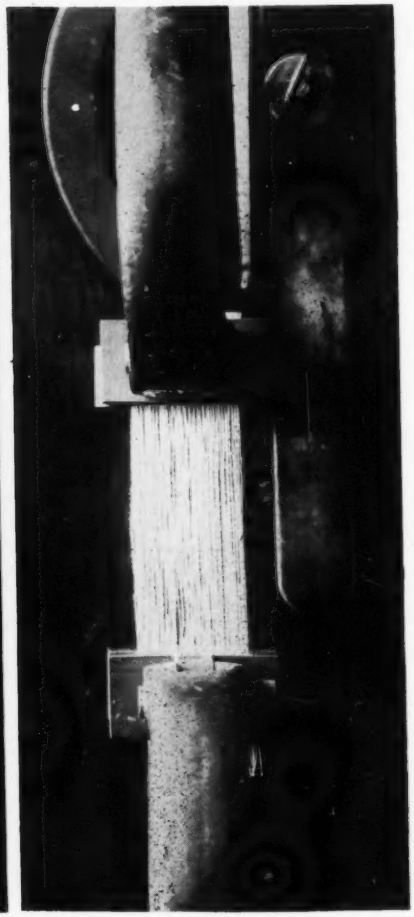
Number of ends in package	*Yards to reel*	*Yards in skein*
1	120	120
2	60	120
3	45	135
4 and 5	30	120 and 150
6 and 7	20	120 and 140
8 and above	15	120 and above

The skein testing is done on a machine of 150 pounds and 300 pounds capacity at a speed of 12 ± ½ inches per minute. Instead of jaws, spools which are at least one inch in diameter and at least one inch wide, of which at least one spool shall be free to turn on its axis are used. The skein is slipped over the spools, opened out into a band, and the slack is held by the hand until the machine tightens it and finally breaks the skein.

In the single strand test, the sample is drawn off from the side of the package; if the yarn is cut into convenient lengths the ends should be knotted to prevent loss of twist. The jaws of the machine may be flat grip, capstan, drum, or any other device which does not have more than 25 per cent of the specimens breaking within ½ inch of the jaw; specimens which break within ½ inch of the jar are discarded. The speed of the lower jaw is 12 ± ½ inches per minute and the gauge length is 10 ± 1/16 inches except

Fig. 40 (Left)—Skein on Spools of Strength Testing Machine.

Fig. 41 (Below)—Serigraph Sample in Jaws of Strength Testing Machine.



in the A.S.T.M. test for rayon which uses an 18 inch gauge length. A large number of tests are necessary for a good average—the A.S.T.M. specifies 50 tests which are free from breaks at the jaw. If the stretch is to be determined, the specimen is put into the machine with a standard initial tension applied by hanging a small weight on the specimen.

The A.S.T.M. test for tire cords specifies single strand tests (at least 6 tests) on a 50 pound capacity machine with cam-clamp jaws and spool of not less than ½ inch diameter, and an initial tension of 4 ounces; otherwise tire cords are tested as in any single strand test.

The serigraph test is so called because of its early association with the silk industry. Haven's method is the simplest and requires no special apparatus. A skein is wound as for the skein test, the yarn is spread out on the arms of the reel and stickers are pasted across the yarn above and below it and 3 inches apart; this sample is cut out of the skein and tested in a strength machine like a cloth strip sample.

The multiple strand method of the Bureau of Standards consists in winding the yarn on two arms united by a fixture (using a modified seriplane), placing the whole thing in the jaws of a strength tester, removing the fixture, and breaking the sample. The gauge length in this case is 4 inches, and the speed of the lower jaw is 6 inches per minute.

The A.S.T.M. serigraph test on rayons is carried out on skeins, using ten skeins of the following number of turns:

Denier of rayon	*Number of turns*
Finer than 51d	400
51 to 76d	200
76 to 121d	150
121 to 201d	100
201d and coarser	50

The machine specified is one with capacities of 25 and 50 kilograms (55 and 110 pounds) and with an autographic recorded. The gauge length is 10 centimeters (4 inches) and the jaw speed is 6 inches per minute. The jaws are covered with one layer of rubber tire tape. The skein is spread out so as to form a ribbon ⅜ to ¾ inches wide, clamped in the jaws, and broken. No stickers or special winding devices are used, and only one break to a skein is made.

Each method of testing has its advantages and disadvantages. The skein test was the earliest used and so is more popular, and much data is available for comparison when this test is used; it will grade a series of yarns in the same relative order as the other tests; a fabric tester may be used by replacing the jaws with spools. In this test, as soon as a few yarns break, the rest of the skein slips, so that the test tends to give low results and not the true breaking strength; the reeling of the skein also affects the result, unequal tension on different circuits of the yarn will give low results by breaking the shortest circuit first and then allowing slippage; in the case of rayon and silk the skein flies all apart as soon as breaking starts and the skein test cannot be successfully used on these fibers. Then too, yarns are not used in the form of skeins, in actual use the load comes onto the individual yarns. The skein test does not give any idea as to the uniformity of the yarn strength; it does not allow of stretch measurements; and it cannot be used for comparing yarns of different fibers.

The single strand test more nearly represents the actual loading of the yarns in weaving; it gives a good idea as to the uniformity of the yarn; it allows of stretch measurements; and smaller samples may be used, so that it is possible to remove short lengths of yarn from knitted or woven goods and test them. On the other hand, a large number of tests must be made if this method is used in order to get adequate sampling and so that the average result will be accurate; a special strength testing machine must be used for this test which is good for no other purpose.

The serigraph test uses a cloth testing machine and jaws; it most nearly represents the strength that the yarns will

show in the cloth; it gives the most consistent results on fine yarns; it gives a good average and adequate sampling if only one test is made to a skein; stretch data may be determined. On the other hand, the test in the A.S.T.M. modification uses a different gauge length and jaw speed from all other tests and therefore the results are not comparable with other tests; the Haven method in this respect is better than the A.S.T.M. or multiple strand test. The serigraph test is the youngest of all the yarn tests and is not well known except in the silk and rayon branches of the textile industry; it combines the good points of both the skein and single strand tests.

It is sometimes desirable to compare the strength of yarns of different counts or denier. The strength of spun yarns may be converted to any specified counts by the formula:

$$N_1 S_1 = N_2 S_2$$

where N = counts and S = strength

The product NS, called the strength-count product, is sometimes used, especially in the case of skein tests to compare different yarns. Rayons and silks are compared by giving the tenacity in grams per denier:

$$\text{Tenacity} = S/D$$

where D = denier

If yarns composed of different fibers are to be compared by the single strand method, the breaking length is calculated; this is the number of yards of yarn having a weight equal to the single strand breaking strength of the yarn, and is supposedly the length of yarn which would break due to its own weight.

$$\text{Breaking length of spun yarns} = \frac{SN \times H}{454}$$

$$\text{Breaking length of rayons and silks} = \frac{S \times 15.4 \times 638}{D} = \frac{S \times 9{,}850}{D}$$

where S = single strand breaking strength in grams
N = counts
H = number of yards in standard hank
D = denier

It will be noted that the formulae for breaking length contain the quantities SN and S/D which are methods of comparison already given.

Fibers may be tested either singly or in bundles. Individual fiber testers have already been described and classified; these tests are slow and laborious and several hundred tests are necessary for a satisfactory average. Bundle tests may be carried out by the Walen method, Grimes method, or the Chandler method (A.S.T.M. standard method). The Walen method consists of parallelizing the fibers by pulling as for staple, brushing out all fibers less than 7/8 inch long cutting the bundles to 7/8 length, and adjusting the bundles to weigh about .004 grams. The ends of the bundles are cemented together with collodion and the bundles are broken in a 10 pound tester with a 1/2 inch gauge length. Five or more bundles are tested and the results are calculated to strength in ounces of fiber equal to a unit of No. 20 yarn by the following formula:

$$\text{Strength} = \frac{\text{sum of strength in pounds} \times 16 \times 454 \times 7}{\text{sum of weights in grams}} \quad \frac{}{840 \times 20 \times 36 \times 8}$$

The Grimes method is similar to the Walen in that the fibers are combed out and cut to a definite length. The bundles are then adjusted to a weight of .025 ± .005 grams, the ends are taped together with drafting tape, and the bundles are broken in an ordinary fabric testing machine. The results are calculated to pounds strength per gram of fiber and are averaged. In the Chandler bundle method, a bundle of fibers is combed out parallel and the bundle is wrapped with No. 20 sewing thread on a special apparatus; the length of thread for 10 revolutions is measured and the circumstance of the bundle is calculated and corrected for the thickness of the thread. The samples are broken in a 300 pound capacity machine with special jaws and each break is corrected to a standard circumference of 0.125 inches; each corrected break is then calculated to pounds per square inch by dividing by the cross-sectional area (0.0012434 square inches); the average of ten breaks is taken.

(To be continued)

BOOK REVIEW

An Introduction to the Study of Spinning by W. E. Morton, M. Sc. Tech., F. T. I. Professor of Textile Technology in the University of Manchester, and Head of the Textile Dept., Manchester College of Technology. Longmans Green and Co., 115 Fifth Ave., New York City, 1938. 268 pages, 161 illustrations. Price $4.50.

In the publication of this book the author has aimed to direct the student's attention in the very beginning to the fundamental nature of the processes through which the raw materials have to go in the course of yarn manufacture; to show how the evolution of the various modern machines from the original handicraft appliances has been influenced in each case by the character of the raw material it was intended to treat; and to exclude as far as possible all references to confusing mechanical complications until there is no longer any risk of their crowding out of the picture the things that really matter. In short, he has endeavored to prepare the ground for later specialization in such a way that the student can proceed to the more advanced stages of his work in a restricted field with a proper sense of proportion and in a more inquiring frame of mind.

The first half of the book is devoted to a description of the textile fibers which serve as raw materials, and the second half to a study of the mechanical principles involved in the manufacture of yarn. The book is well written and excellently illustrated. Should serve as a valuable text to the student who wishes to get an insight into the process of yarn making.

TRADE NOTES • NEW PRODUCTS

• CALCO'S AZO CIRCUS

A novel presentation of sample swatches was utilized in a mailing campaign by Calco Chemical Company which started last July and was concluded in February of this year. A series of ten animals, dyed with the particular dye being advertised, was sent out at intervals of three weeks. The trades covered were the wool, cotton, rayon, leather and paper and the animals sent to each trade were made of the material common to that trade, e.g., men in the woolen trade received animals dyed on wool, in the cotton trade animals dyed on cotton, etc. The recipients were asked to take the animals home to their children, to make a collection of all ten animals, and when the child had the complete collection it was to write to Calco who would send it a set of performing clowns. If the child were too young to write its own letter, it was permissible for the father to "ghost write" the letter. Two of the letters received by Calco are reproduced herewith. Carrying the circus spirit further Calco salesman had monthly contests on the sale of azo dyes for the title of champion tight rope walker, champion weight lifter, etc. Trade paper advertising also tied in with the circus idea and featured animals. Calco reports that returns from the mailings of the animals were exceptionally good and enough circus sets were reserved for all who had a complete collection. A letter was received from a night watchman who said he had been saving the animals by rescuing them from the scrap basket and asked for another elephant and another bear, demonstrating that the mailing pieces had a certain amount of advertising value even after they had been thrown away. The ten animals which comprised the azo circus group were the: elephant, bear, fox, monkey, camel, lion, seal, buffalo, kangaroo and hippopotamus.

• MEETING, A.A.T.T.

A meeting of the American Association of Textile Technologists was held at the Architectural League, 115 East 40th Street, New York City, on the evening of March 2nd, at which time 55 members and guests were present. The principal speaker of the evening was Mr. Henry A. Gassman, Textile Analyst, United States Customs Laboratory, New York City.

• GENERAL RELEASES

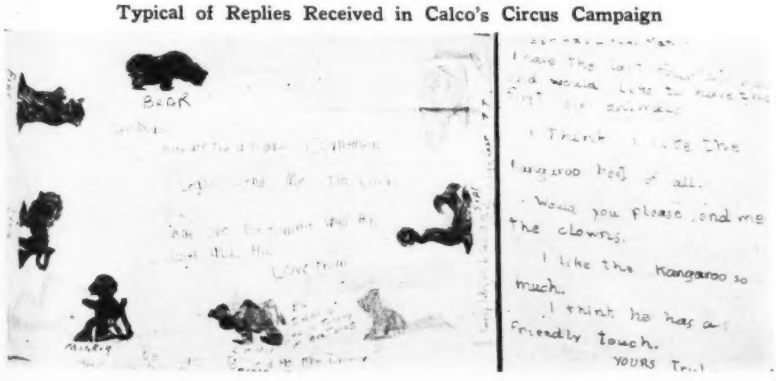
General Dyestuff Corp., 435 Hudson Street, New York, N. Y., announces release of circulars on the following products:

Diazo Brilliant Orange G G A Extra Conc.—which, when diazotized and developed with Developer A, produces on cotton or on rayon bright shades of a yellowish orange; the color is particularly recommended by the manufacturers on account of its very good fastness to washing and its excellent dischargeability. It is said to be valuable for self shades as well as for brown combinations which must be dischargeable. Circular G-167.

Benzo Brown B A—which is said to produce a very good union shade of a deep bluish brown on rayon-cotton, leaving acetate rayon very clear and staining animal fibers only very slightly. Circular I.G. 1333.

Indanthren Olive Green G G Powder Fine For Dyeing—a new homogeneous vat dyestuff of the I N series which produces shades much yellower than Indanthren Olive Green B A. It is said that, in addition to having good solubility and levelling properties, it also possesses maximum fastness to light. On account of its resistance to outside exposure, it is recommended by the manufacturers for the dyeing of awning stripes. It is claimed further that it has the important property of covering dead cotton and producing uniform shades on mixed fabrics containing cotton and viscose rayon. Circular I.G. 1415.

Typical of Replies Received in Calco's Circus Campaign


BEAR
I Think I like the kangaroo best of all.
Would you please send me the clowns.
I like the Kangaroo so much.
I think he has a friendly touch.
YOURS Truly

• MARCH TEXTILE RESEARCH

In an article on "Twist Measurements in Single Yarns," in the March issue of Textile Research, E. R. Schwarz discusses proper and improper sampling, technique and interpretation of data. Apt in this connection is his statement: "It is important that yarns be twisted. It is tragic if the investigator is twisted too."

In the same issue Harry A. Mereness, director of technical research, National Federation of Textiles, presents and discusses formulae for the strip-grab relations for some staple dress fabrics, as derived from the plotting of a large number of breaking strength tests. Because of the lack of correlation between strip and grab test results, he suggests the need of extended scientific study of the whole subject under rigorously controlled conditions.

Dr. Charles H. Herty, renowned research and industrial chemist, is lauded in this issue for his pioneering research which has resulted in the establishment in the southeastern states of $100,000,000 worth of new kraft paper enterprises, and also for his many notable services to the textile industry. Incidentally, it is noted that if it had not been for his devotion to his slash pine research, which has produced such outstanding results, he might have been the second president of U. S. Institute for Textile Research.

• NEW ENGLAND SALES MANAGER

Jacques Wolf & Co., Manufacturing Chemists and Importers, Passaic, N. J., announce, effective March 1, 1938, the appointment of Walter D. Deuble as New England District Sales Manager, with headquarters at 126 Pawtuxet Ave., Edgewood, R. I. Mr. Deuble has been with Jacques Wolf 25 years, covering New England the last 20 years.

• WEEK-END COURSE

Modern textile testing and research methods will be the subject covered by a special program to be offered on ten successive Saturdays beginning April 2, 1938, by the Massachusetts Institute of Technology under the direction of Professor Schwarz and the staff of the Textile Laboratory.

In addition to demonstrations and conferences, laboratory exercises have been arranged to provide opportunity for a limited number of mill men and others interested in this work to use equipment for the microscopical and physical analysis of fiber, yarn and fabric and to familiarize themselves with the newer techniques for the identification of fibers, and the measurement of different properties of textile materials. Research progress in this

country and abroad will be reviewed and the trend of the future development of textile technology will be outlined. Application must be made to the Textile Laboratory at the Massachusetts Institute of Technology before March 26.

• ELECTED DIRECTOR

Wheeler McMillen, president of National Farm Chemurgic Council and editorial director of The Country Home, has been elected a director and vice-president of The Chemical Foundation, Inc., it was announced recently.

Mr. McMillen succeeds the late Francis P. Garvan as a director of The Chemical Foundation. In assuming the vice-presidency, Mr. McMillen becomes the ranking officer of the Foundation since no immediate successor is proposed for the office of president which was held by Mr. Garvan, who, during the 18 years he directed the Foundation, played a major role in the development of the American Chemical Industry and the Chemurgic movement.

The Chemical Foundation will continue its support of research development in the chemical, scientific and medical fields, according to William W. Buffum, treasurer and general manager. Particular emphasis will be placed upon activities tending toward establishment of new Chemurgic industries through the use of farm products as industrial raw materials.

• INJUNCTION GRANTED

A permanent injunction has been granted by Justice Thomas F. Noonan at a special session of the New York Supreme Court enjoining the United States Fur Testing Laboratories, Inc., and Maurice Filson from doing business under that or a similar name or the use of the words or combination of words "United States" and "Testing" which are likely to deceive or confuse the public with the name of the United States Testing Company, Inc.

The action was brought by the United States Testing Company, Inc., a nationally known testing organization upon the ground the use of a name so similar to its own was used to mislead the public.

• DU PONT AT WORLD'S FAIR

Plans for an exposition building at the New York World's Fair, to house a series of dramatized exhibits depicting the social contributions of the modern chemical industry were announced recently by E. I. du Pont de Nemours & Company.

The structure will have as its central feature a huge semi-cylindrical shell, 70 feet high, decorated with one of the largest mural paintings ever executed. The shell wall partially encloses a court affording entrance to the building, centering about a 100-foot tower typifying the spirit of chemical research.

The mural will be a symbolic one, portraying the significance of the chemist in industry, transportation, agriculture, mining and other fields. Its figures will be painted on an heroic scale, some being over 30 feet in height. The tower, a formalized representation of a chemical apparatus, will make use of color, active liquids in circulation and changing lights to achieve the spectacular effect sought.

Designed along strictly functional lines, the building itself will be finished in stucco, painted white, with blue walls at the rear and sides. It is also semi-circular in shape, with set-backs accentuating the plan. Foundation work will start in the spring, it is expected, with completion next fall, some months before the opening of the fair on April 30, 1939. All over cost of the exhibit is estimated at $500,000.

The du Pont exhibit will be called "The Wonder World of Chemistry." Inside the building, visitors will follow a long circular corridor designed to carry out the atmosphere of a laboratory. Chemical products and processes will be displayed here, and explained by commentators. A number of animated displays showing actual chemical processes will be shown. The hall leads ultimately to a large central room where the theme of the exhibit will be summed up in terms of the practical application of the industry in influencing style, beauty, economics, the home, health, safety and other phases of modern life.

The entire building will be air-conditioned. An office and conference room are located on the second floor. Walter Dorwin Teague is the designer, with Robert J. Harper associate and A. M. Erickson engineer.

• ALTHOUSE RELEASE

Althouse Chemical Co., Reading, Pa., has released a color card described by the following title:

Azoanthrene Fast Colors for Package Machine Dyeing—illustrating a series of dyes for rayon, cotton, silk or unions which are said to be faster to washing than developed colors. It is stated that Azoanthrenes become insoluble with the addition of Parathol, a new method of producing fast to washing colors. The chemical construction of these dyes is such, that they react at low temperatures with Parathol to form an insoluble compound, which cannot be dissolved with the usual dyehouse reagents, it is claimed. It is said that the usefulness of this invention is that the dyeing of Azoanthrenes is as simple as the dyeing of direct colors. Other claims made for this series of dyes are: discharge as good or better than direct or developed colors; fast to acid or alkaline perspiration and are good to hot pressing; can be fulled; dye cotton heavier than wool and can be dyed in conjunction with fast to fulling Anthra Milling Colors; fast to washing shades on hosiery can be dyed with these colors; Azoanthrenes are also useful for silk because they have a clear discharge with a heretofore unobtainable washing fastness. The card gives dyeing instructions for these colors and there are a number of swatches illustrating them. The swatches are unique in that they show the complete cross-section of a dyed cone.

CLASSIFIED

The rate for "Position Wanted" advertisements in this column is 2 cents a word—with a minimum of 50 cents per insertion. For all other types of advertisements—i.e., help wanted, machinery or supplies for sale—the rate is $5.00 per column inch or less per insertion.

POSITION WANTED: Finishing plant chemist desires responsible position. Expert on vats, napthols and other cotton and rayon dyeing. All types of control work and testing. 26 years' experience on yarn and piece goods. Write Box No. 993, American Dyestuff Reporter, 440 Fourth Ave., New York, N. Y.

POSITION WANTED— Chemical engineering graduate—1936—interested in chemical sales. Experienced selling textile oils and specialties. Desires position with reliable concern. Write Box No. 109, American Dyestuff Reporter, 440 Fourth Ave., New York, N. Y.

POSITION WANTED—By textile chemist experienced in the development and manufacturing of Sulfonated Oils, Softeners, Penetrants, Delusterants, Sizes, Splash-proofing, Finishes, etc. Thoroughly capable of conducting or directing research and following products from laboratory scale to plant operation. Experience with Colloidal Mills and Homogenizers. Salary reasonable. Write Box No. 112, American Dyestuff Reporter, 440 Fourth Ave., New York, N. Y.